The
Philippine Agriculturist

VOL. X, NO. 5 DECEMBER, 1921

TWO YEARS OF SWEET POTATO BREEDING[1]

By Nemesio B. Mendiola
Of the Department of Agronomy, Division of Genetics

FRONTISPIECE AND TWO PLATES

OBJECT

The main object of this work was not to obtain an ideal variety of sweet potato, or one "made to order," so to speak, but rather to find out if new varieties may be produced by propagating the plant sexually.

Like the sugar cane, the sweet potato has been propagated almost exclusively by cuttings. It was anticipated, therefore, that the method which had been so successful in the production of superior sugar cane varieties would be found to give success with this root crop. It was thought that if in this work it is found that seeds are produced in abundance and that these seeds will germinate, then the work could later be modified and carried on with the aim of producing a variety with definite characteristics. Moreover, it was believed that if a great variability is met among the seedling offspring of each variety, it would be quite possible that even in this way, that is merely growing such seeds as are produced without artificial cross-pollination, some varieties might be produced which would be superior in one or several respects to those which are already existing.

FIRST YEAR EXPERIMENTS

THE FLOWER

Previous to 1919, our College sweet potato cultures, though they included many varieties, had not produced more than about a dozen seeds each culture. For this reason, this experiment, which Dean Baker during the whole period of his connection with this institution had wanted the Agronomy Department to undertake, could not be started.

Suspecting that the failure to get more seeds might be due to possible absence of pollination, an examination was made of the structure of the flower of the different varieties. Plate II, figs. 1-5, shows diagram-drawings of typical flowers as regards the relative position of anthers and stigma. The flower of sweet potato is hermaphroditic. It will be seen that some varieties are not adapted to self-pollination because, in nature, the flowers are borne more or less erect and the anthers are below the stigma.

[1] Experiment Station contribution, No. 58.

POLLINATION

Convinced that there was an absence of pollination, plant breeding students were, in the latter part of November, 1919, instructed to perform self-pollination work with the different varieties of sweet potato to force the production of seeds. However, this treatment was not very successful in making seeds develop.

Upon examination of the cultures again in the latter part of December, it was found that several varieties had produced seeds in abundance and that bees, which belong to the species *Apis indica* Fab.,[2] were serving as agents in pollination. When several of these bees were caught and examined, their bodies were found partly covered with sweet potato pollen grains. A bee was observed in its work of visiting the flowers and it was seen that it can, indeed, serve as an effective agent in pollination, for in crawling from the mouth of the corolla to the nectary and turning about while inside the flower, and then coming out again, the body rubs against the pollen grains and the stigma. In this way self-pollination, and even cross pollination, when different varieties are flowering side by side, are possible.

THE SEED

Plate II, figs. 6-7, shows drawings of several sweet potato fruits including one which was enlarged about four times. The fruit is one-to two-seeded. If the seeds are not gathered soon after they mature, they fall to the ground and usually get lost in this way among the vines and dried leaves.

VARIETIES FROM WHICH SEEDS WERE GATHERED

Table I shows the varieties from which seeds were gathered and, in a relative way, the abundance of the seeds in each variety.

TABLE I.—*Varieties used and number of seeds gathered.*

College No.	Variety name.	Number of seeds gathered.
1454	Big Jersey	4
10958	New Jersey	5
333	Samar Big Yellow	173
9313	Kariis	4
3893	Boled Zooling	56
	Binandera	51
	Bulakeña	38
	Unknown	70
5795	Pangloo	19

CULTURES

Plantings of seeds of the varieties shown in Table I, as well as of the variety, Binglo, were made in seed boxes on January 5 and 6, 1920. The seeds germinated very readily, requiring only from two to three days. When the seedlings were

[2] Determination by C. F. Baker, dean, College of Agriculture.

about one decimeter high they were transplanted to a plot where they were distanced 1 meter by 0.5 meter.

The cultures of Samar Big Yellow were harvested on December 14, 1920, and of the other varieties on January 5, 1921. In the opinion of the author, the soil in which the seedlings were planted, as well as the care they were given, is not what might be termed the best for sweet potato.

RESULTS

Only from the following varieties were results obtained: Samar Big Yellow, Binandera, Binglo, Boled Zooling, and three unidentified varieties which, for the sake of convenience, are designated as Unknown B, Unknown C, and Unknown D.

SAMAR BIG YELLOW

Variability of shape of leaf of the offspring.—One hundred of the 205 offspring of Samar Big Yellow were studied for variability in leaf shape. It was found that there were twenty-eight types; these are shown in Plate I and designated as Shape A, B, C, etc., to Z. The frequency distribution and corresponding pedigree numbers of these shapes are shown in Table II.

It may be pointed out that shape G, which is the predominating shape, is not the shape of the leaf of the parent.

Color of tubers.—Samar Big Yellow has a pinkish-yellow skin and yellowish-purple flesh. The offspring varied in color. Some were red, others were yellowish-white, white, and yellow. Some individuals produced uniform colored tubers not only as to the skin but also as to the flesh. Many individuals, however, produced tubers of different colors. Offspring 121 produced both whitish-yellow and yellow tubers. The flesh varied from white to yellow with purple markings.

TABLE II.—*Showing frequency distribution of leaf shapes A to Z (See Plate I) and pedigree numbers of offspring of Samar Big Yellow.*

Leaf shape.	Frequency.	Pedigreé numbers.
A	6	1, 103, 49, 158, 160, 172.
B	6	114, 2, 25, 111, 26, 50.
C	2	3, 32.
D	3	16, 4, 122.
E	4	136, 5, 107, 39.
F	3	35, 6, 118.
G	16	149, 7, 62, 24, 8, 29, 72, 21, 91, 19, 20, 47, 42, 45, 100, 172.
H	9	109, 9, 22, 176, 116, 48, 58, 174, 173.
I	5	132, 34, 10, 61, 152.
J	2	11, 156.
K	5	120, 70, 12, 43, 27.
L	5	44, 67, 15, 13, 88.
LL	2	102, 180.
M	2	117, 67.
N	2	23, 95.
O	5	28, 73, 124, 31, 162.
P	1	66.
Q	4	132, 104, 69, 115.
R	4	123, 119, 40, 113.
S	5	18, 101, 99, 163.
T	2	14, 165.
U	2	146, 170.
V	1	150.
W	2	33, 87.
X	1	38.
Y	1	60
Z	1	85.

Some of the tubers in cooked condition were very attractive with respect to fancy color of flesh. Altogether, out of nearly 200 individuals studied, eight showed promise in this respect. These are Nos. 8, 37, 54, 98, 108, 112, 120, and 137. The flavor of these varied from fair to very good. They were not fibrous.

Flavor.—Seven out of 205 individuals promised superiority in delicacy of flavor. (In this and the other varieties studied, flavor was determined by test-

ing cooked samples of tubers only two or three days after harvest.) These were Nos. 5, 13, 17, 59, 106, 121, 138, 184, 185, 191, 203, 204, and 205. No. 59 was somewhat fibrous. The rest were more desirable in this respect.

Yield.—Table III shows the record of yield of tubers of the different offspring.

TABLE III.—*Weight of tubers produced by seedling offspring of Samar Big Yellow.*

Off-spring No.	Wt. of tubers produced.	Off-spring No.	Wt. of tubers produced.	Off-spring No.	Wt. of tubers produced.	Off-spring No.	Wt. of tubers produced.
	gm.		*gm.*		*gm.*		*gm.*
1	177.3	53	49.8	104	0.0	155	1441.0
2	367.7	54	181.6	105	157.4	156	181.8
3	20.0	55	260.9	106	252.4	157	129.0
4	168.8	56	16.6	107	50.5	158	104.1
5	166.7	57	24.8	108	39.5	159	134.2
6	93.5	58	0.0	109	174.0	160	127.0
7	16.5	59	98.5	110	236.0	161	233.5
8	8.2	60	119.2	111	0.0	162	246.8
9	0.0	61	0.0	112	53.1	163	153.1
10	0.0	62	0.0	113	0.0	164	0.0
11	0.0	63	157.3	114	0.0	165	72.2
12	0.0	64	18.0	115	0.0	166	79.3
13	291.0	65	0.0	116	204.0	167	211.7
14	21.5	66	110.1	117	87.5	168	370.9
15	0.0	67	37.3	118	0.0	169	129.5
16	0.0	68	112.9	119	815.0	170	24.8
17	703.3	69	39.1	120	6.0	171	241.0
18	0.0	70	88.0	121	2802.0	172	427.1
19	0.0	71	65.7	122	71.9	173	0.0
20	0.0	72	55.6	123	101.7	174	674.0
21	0.0	73	79.2	124	0.0	175	206.0
22	265.4	74	143.5	125	74.2	176	0.0
23	286.2	75	0.0	126	369.2	177	136.0
24	24.9	76	0.0	127	81.0	178	114.3
25	198.5	77	0.0	128	0.0	179	329.0
26	0.0	78	0.0	129	340.5	180	0.0
27	94.8	79	0.0	130	244.7	181	122.0
28	73.0	80	0.0	131	124.0	182	42.0
29	0.0	81	0.0	132	962.0	183	70.0
30	79.8	82	0.0	133	99.5	184	127.3
31	6.4	83	0.0	134	23.2	185	542.0
32	199.3	84	0.0	135	244.7	186	103.5
33	0.0	85	35.9	136	137.8	187	520.0
34	100.1	86	10.3	137	63.2	188	64.0
35	13.2	87	0.0	138	306.4	189	1020.0
36	0.0	88	0.0	139	300.5	190	42.0
37	36.4	89	62.7	140	0.0	191	177.0
38	0.0	90	0.0	141	431.1	192	67.0
39	0.0	91	66.8	142	1128.1	193	265.0
40	31.1	92	17.6	143	276.3	194	210.0
41	150.3	93	0.0	144	565.4	195	134.0
42	136.3	94	0.0	145	215.8	196	52.0
43	26.3	95	0.0	146	350.9	197	115.0
44	0.0	96	0.0	147	75.8	198	0.0
45	0.0	97	0.0	148	170.8	199	277.0
46	0.0	98	28.5	149	0.0	200	221.0
47	0.0	99	419.0	150	131.3	201	98.0
48	0.0	100	0.0	151	233.2	202	5.0
49	53.2	101	0.0	152	81.9	203	267.0
50	0.0	102	0.0	153	180.3	204	165.0
51	368.3	103	11.3	154	740.3	205	175.0
52	56.5						

The results in Table III are placed in a frequency table, (Table IV).

TABLE IV.—*Frequency distribution of yield of tubers of 205 seedling offspring of Samar Big Yellow.*

Class values.	Frequency.
gm.	
0-0	62
1-200	97
201-400	31
401-600	6
601-800	3
801-1000	2
1001-1200	2
1201-1400	0
1401-1600	1
1601-1800	0
1801-2000	0
2001-2200	0
2201-2400	0
2401-2600	0
2601-2800	0
2801-3000	1

From Table IV it will be noticed that the "mode" and hence the typical class is 1-200 grams. Considering this fact, the yield of 2802.0 grams of offspring No. 121 may well be considered very exceptional.

BINANDERA

From the culture of this variety only ten plants survived. The yield of tubers of these was as follows:

TABLE V.—*Weight of tubers produced by seedling offspring of Binandera.*

Offspring No.	Wt. of tubers produced	Offspring No.	Wt. of tubers produced
	gm.		*gm.*
1	127	6	95
2	380	7	340
3	1090	8	2333
4	75	9	430
5	107	10	70

Of the ten offspring of Binandera, Nos. 8 and 3 were selected for high yield and No. 4 for fine flavor.

BINGLO

Table VI shows the record of yield of the offspring of Binglo.

TABLE VI.—*Weight of tubers produced by seedling offspring of Binglo.*

Off-spring No.	Wt. of tubers produced.	Off-spring No.	Wt. of tubers produced.	Off-spring No.	Wt. of tubers produced.	Off-spring No.	Wt. of tubers produced.
	gm.		*gm.*		*gm.*		*gm.*
1	34.8	26	0.0	51	721.0	76	39.5
2	92.0	27	772.0	52	20.0	77	0.0
3	——	28	116.0	53	290.0	78	0.0
4	9.2	29	120.0	54	——	79	0.0
5	312.3	30	159.7	55	203.4	80	0.0
6	44.5	31	211.0	56	0.0	81	0.0
7	55.0	32	0.0	57	0.0	82	274.8
8	151.0	33	314.5	58	399.0	83	85.0
9	165.0	34	324.8	59	349.5	84	190.0
10	——	35	252.4	60	378.2	85	173.0
11	43.5	36	588.1	61	75.5	86	175.0
12	35.2	37	229.0	62	108.0	87	551.5
13	24.2	38	701.5	63	18.0	88	635.0
14	31.3	39	24.0	64	368.0	89	210.0
15	29.5	40	105.5	65	14.7	90	90.0
16	454.8	41	109.2	66	119.5	91	110.0
17	299.0	42	142.0	67	123.1	92	263.0
18	68.0	43	248.0	68	43.2	93	77.0
19	——	44	0.0	69	0.0	94	445.0
20	397.5	45	157.0	70	22.5	95	103.0
21	——	46	197.8	71	0.0	96	60.0
22	535.0	47	271.5	72	0.0	97	360.0
23	479.9	48	220.8	73	387.0	98	575.0
24	87.0	49	257.5	74	0.0	99	170.0
25	251.0	50	486.5	75	30.1	100	60.0

Nos. 27 and 38 were selected on account of their high yield and Nos. 83, 86, 90, 91, 95, and 96 on account of good flavor.

BOLED ZOOLING

TABLE VII.—*Number and weight and color of skin and flesh of tubers produced by seedling offspring of Boled Zooling.*

Offspring No.	Wt. of tubers.	No. of tubers.	Color of skin.	Color of flesh.
	gm.			
1	307.9	1	White	Pale yellow partly tinged with purple
2	224.6	2	White	White
3	64.1	2	1st; white	1st; white
			2nd; yellow	2nd; purple and yellow
4	115.5	4	Purple	White
5	115.6	4	White	White
6	227.0	3	White	White
7	73.6	2	White	White
8	——	——	——	——
9	142.2	3	White	White
10	0.0	——	——	——
11	0.0	——	——	——
12	0.0	——	——	——
13	217.0	1	White	White

Offspring Nos. 1 and 4 were found superior in flavor.

UNKNOWN B

Six seedlings of this variety survived to maturity. They were numbered 1, 2, 3, 4, 5, and 6. They yielded 0.0 gm., 0.0 gm., 98.0 gm., 3.8 gm., 454 gm. and 1369 gm. of tubers respectively.

SECOND YEAR EXPERIMENTS

CULTURES

Plantings were made on December 21, 1920, and on January 8, 1921. The seedling varieties used in the second year tests were:

Samar Big Yellow.—Nos. 8, 37, 98, 108, 112, 120 and 137 all of which were selected for fancy color; Nos. 5, 13, 17, 59, 106, 121, 184, 185, 191, 203, 204 and 205 for delicacy of flavor; Nos. 2, 17, 121, 142, 135, 155, and 185 for promising yield.

Binandera.—Nos. 3 and 8 for yield and No. 4 for flavor.

Binglo.—No. 38 for yield and Nos. 83, 86, 90, 91, and 95 for flavor.

Boled Zooling.—Nos. 1 and 4 for flavor.

Unknown B.—No. 6 for yield.

Unknown C.—No. 4 for flavor.

UNKNOWN C

TABLE VIII.—*Weight and color of skin and flesh of tubers produced by seedling offspring of Unknown C.*

Offspring No.	Wt. of tubers.	No. of tubers.	Color of skin.	Color of flesh.
	gm.			
1	164.1	1	White	White with purple tinge
2	68.0	1	White	White and purple
3	230.9	2	White	Light purple and white
4	409.0	1	Yellow	Yellow and purple
5	17.0	1	White	White with purple tinge
6	24.2	1	Purplish yellow	Purple yellow
7	——	——	——	——
8	151.5	1	Purple	White with light purple tinge
9	453.8	3	White	White with purple tinge
10	273.0	4	White	Dark purple with white tinge

Seedling No. 4 proved superior in flavor.

UNKNOWN D

TABLE IX.—*Weight of tubers produced by seedling offspring of Unknown D.*

Offspring No.	Wt. of tubers produced.	Offspring No.	Wt of tubers produced.
	gm.		*gm.*
1	35.0	8	260.0
2	175.0	9	44.0
3	64.5	10	93.0
4	580.0	11	392.5
5	390.5	12	95.0
6	125.0	13	290.0
7	190.0	14	305.0

The varieties planted on January 8, 1921, were Samar Big Yellow Nos. 59, 184, 185, 191, 203, 204 and 205; Binandera Nos. 3, 4, and 8; Binglo Nos. 83, 86, 90, 91 and 95. All the others were planted on December 21, 1920.

The land used in the second year plantings was of the same type as that of the first. It is rather heavy, low, and not well drained.

Samar Big Yellow No. 17 flowered at the age of 56 days while Nos. 2, 106 and 135 flowered at the age of 71 days. A record of flowering of the other variety was not taken.

The cultures were harvested on October 10 and 11, 1921. The varieties which were planted on December 21, 1920, were at the time of harvest about 294 days old, while those planted on January 8, 1921, were about 276 days old.

RESULTS

The results which were obtained from the second year tests are shown in Table X. The yield results of the first year cultures were included in the table for comparison with those of the second year.

TABLE X.—*Yield of first generation seedlings of different sweet potato varieties and yield of cuttings from seedlings.*

Pedigree No.	First year (seedling) yield of tubers.	Second year (cutting) yield.		Purpose for which seedling was saved after first year elimination.
		Av. yield of tubers per cutting.	Number of cuttings giving yield.	
S. B. Y.	*gm.*	*gm.*		
8	8.2	230.3	8	fancy color
37	36.4	——	dead	fancy color
98	28.5	3120.8	3	fancy color
108	39.5	101.1	3	fancy color
112	53.1	——	dead	fancy color
120	6.0	167.3	11	fancy color
137	63.2	397.9	6	fancy color
5	166.7	396.8	4	flavor
13	291.0	49.4	4	flavor
17	703.3	565.6	11	flavor, yield
59	98.5	316.8	6	flavor
106	252.4	39.1	2	flavor
121	2802.0	——	dead	flavor, yield
184	127.3	——	dead	flavor
185	542.0	171.5	2	flavor, yield
191	177.0	52.2	2	flavor
203	267.0	49.0	1	flavor
204	165.0	162.8	3	flavor
205	175.0	97.9	7	flavor
2	367.7	435.0	2	yield
142	1128.1	767.8	3	yield
135	244.7	314.0	6	yield
155	1441.0	40.0	1	yield
Ba.				
3	1090.0	312.6	3	yield
4	75.0	341.4	9	flavor
8	2333.0	264.4	10	yield
Blo.				
38	701.5	451.4	6	yield
83	85.0	——	dead	flavor
86	175.0	——	dead	flavor
90	90.0	——	dead	flavor
91	110.0	313.7	4	flavor
95	103.0	473.3	3	flavor
B. Z.				
1	307.9	239.7	3	flavor
4	115.5	——	dead	flavor
U. B.				
6	1367.0	400.6	2	yield
U. C.				
4	409.0	418.2	12	flavor

DISCUSSION OF RESULTS

PRODUCTION OF SEEDS

It has been shown in this work that in December, 1919, there were varieties of sweet potato which produced seeds and that among these varieties Samar Big Yellow was the most prolific. Artificial self-pollination failed to force the production of seed; the flowers which were self-pollinated and bagged fell to the ground before the ovary could develop. It would seem that the bee (*Apis indica* Fab.) was the pollinating agent which caused the production of seeds, at least in those varieties in which the relative position of the anthers and stigma is not adapted to natural self-pollination.

VARIABILITY AMONG SWEET POTATO SEEDLINGS

As was anticipated, there was found great variability among the seedlings which were grown from each parent variety. This variability was easily noted in such characters as shape of the leaf, yield in tuber, color of skin of the tubers, color of flesh of the tuber, and flavor. It was possible that no less a variability was present in other less conspicuous characters which were not included in the observation. Variability was also observed among the tubers of some individual plants as regards color, not to mention size and shape, which are both influenced, however, by age.

It was possible that there was a slight error in the observation of variability, for in the cultures there was a certain amount of overlapping of vines, and it was not impossible that the vines of one plant might have produced a tuber near the hill of another plant. To eliminate this error it is planned to plant individual seedlings or cuttings four meters, at least, each way. Less than this distance is not advisable.

The variability which was found among the seedlings of each variety may be taken as an indication that some of the varieties of sweet potato, which have been propagated asexually up to the present time, are heterozygous with respect to a number of characters.

ISOLATION OF SUPERIOR SEEDLING VARIETIES

Three types of seedling offspring were isolated after the first year test. One type was selected for yield, another for flavor, and a third for fancy color. An example of fancy color type is shown in the frontispiece. Some were really selected for a double purpose, that is, while they were primarily selected for flavor, for example, they were incidentally selected, also, for yield.

A comparison of the yield results in the first year with those in the second, shows that the value of a seedling variety can not be decided by one or two tests. A variety may give a very poor yield the first year and an exceptionally good yield the second year. The reverse may be true also. For this reason, practically all of the seedling varieties which were grown, and survived, in the second year experiment will be tested for several years more. Two of these varieties, however, have shown in both years such good promise that they will be planted in third year of test on a fairly large scale so that enough cuttings may be obtained for trials outside the College Farm. These are S. B. Y. 98 and Blo. 38. The description of these follows and also their descriptive formulae. The method by

which the formulae were found is the same as that which was adopted and expanded by Muñoz [3] and used by other students of sweet potato.

By reference to the formulae of the known varieties, it was determined that S. B. Y. 98 and Blo. 38 are really new types.

DESCRIPTION AND FORMULA OF S. B. Y. 98

Formula: A4, B1, C1, D2, E2, F2, G1, H2-3 I4, J6, (Purple with yellow tinge) K1, L1. Stem, 5 meters long; about 3 to 6 mm. in diameter; pale green with slight tinge of purple when young, the tinge becoming more distinct when old; hairs not abundant; leaves, cordate; mature average leaf 6-8 cm. wide; 7-9 cm. long; young leaf, purple with slight tinge of green; old leaf, green with purplish veins on the nether surface; hairs present on midrib of old leaves; star absent; mature petiole 7-11 cm. long; petiole with abundant hairs when young, disappearing with age, except those at base of petiole; vegetation very vigorous, vines very vigorous; matures fairly early; tubers roundish to somewhat elongated; medium to very big; almost free from disease; skin, reddish purple; flesh, outer portion yellowish, with ring of purple next, tinged with slight yellow; central portion more yellowish; latex, little; cooked tuber skin becomes dull brown; flesh, purple and yellow, colors become deep; smell fine; fairly sweet; sticky; not fibrous; superior in fancy color and for sweet purposes. Flowers abundantly; a superior yielder.

DESCRIPTION AND FORMULA OF BLO, 38

Formula: A4, B1, C1, D1, E2, F2, G1, H3, I4, J2-5, K3, L1. Stem, about 3.5 m. long; 4-6 mm. in diameter; green; hairs abundant; leaves cordate; 7-9 cm. across; 8-10 cm. long; young leaf, dull purple with dull green tinge; old leaf, green but with slight tinge of purple on veins on lower surface; hairs, short, present only at margin; star absent; mature petiole 6-14 cm. long; hairs present on both young and mature petiole, scanty on old; vegetation not vigorous; vines fairly vigorous; matures fairly early; tubers, roundish to somewhat elongated; medium to very big; not all free from disease; skin light purple; flesh, cream colored with circular area tinge with purple; latex, little; cooked tuber-skin dull purple, flesh creamish yellow; smell, fine; fairly sweet; sticky, not fibrous; good yielder.

SUMMARY OF CONCLUSIONS

1. A number of sweet potato varieties have been propagated sexually.
2. There was a great variability among the sexual offspring of each variety.
3. After the first year test of the seedling varieties produced in this work, quite a number of them was eliminated on the supposition that they were not promising. The second year test showed, however, that a one-or two-year test is not sufficient to decide which varieties are superior and which are less desirable. In the light of these results, it would appear really advisable, to save during the first few years of the work as many new varieties as facilities will allow, and to make final elimination only after sufficient data about their comparative merits are obtained.
4. In the tests, plants may well be distanced at least four meters each way, to facilitate digging and to eliminate mixture of tubers of different plants in the soil.

[3] Muñoz, A. R. Identification and tests of varieties of sweet potato. **Philippine Agriculturist and Forester 3:** 127-145. 1914.

5. As a result of the two years of sweet potato breeding work herein reported, two *new* seedling varieties have been found as very probably superior. These bear the College pedigree designations, S. B. Y. 98 and Blo. 38; and will be introduced on outside farms as such.

ACKNOWLEDGEMENT

The author desires to acknowledge the encouragement given in this work by Dean C. F. Baker, and the help rendered by the 1920-1921 and 1921-1922 Genetics classes and by Mr. Juan Unite and Mr. José Capinpin, both graduate assistants in Genetics. Thanks are due Cornelio C. del Rosario for redrawing the illustrations shown in Plate I and to Mr. Moises Villaluz of the School of Fine Arts for drawing the colored plate shown in the frontispiece.

ILLUSTRATIONS

FRONTISPIECE

Opened cooked tuber of a seedling variety of sweet potato selected for flavor and high color of flesh.

PLATE I

Variation in shape of leaf of 100 seedling sweet potato plants which were grown from seeds of Samar Big Yellow variety.

PLATE II

Details of reproductive organs of sweet potato.

Fig. 1—Relative position of anthers and stigma in flower of variety Beriberi.
Fig. 2—Variety, Canegro.
Fig. 3—Variety, Kapapas.
Fig. 4—Variety, Samar Big Yellow.
Fig. 5—Variety, Kariis.
Fig. 6—Sweet potato seeds and fruit enlarged about two times.
Fig. 7—A piece of vine on which are a flower and some fruits.

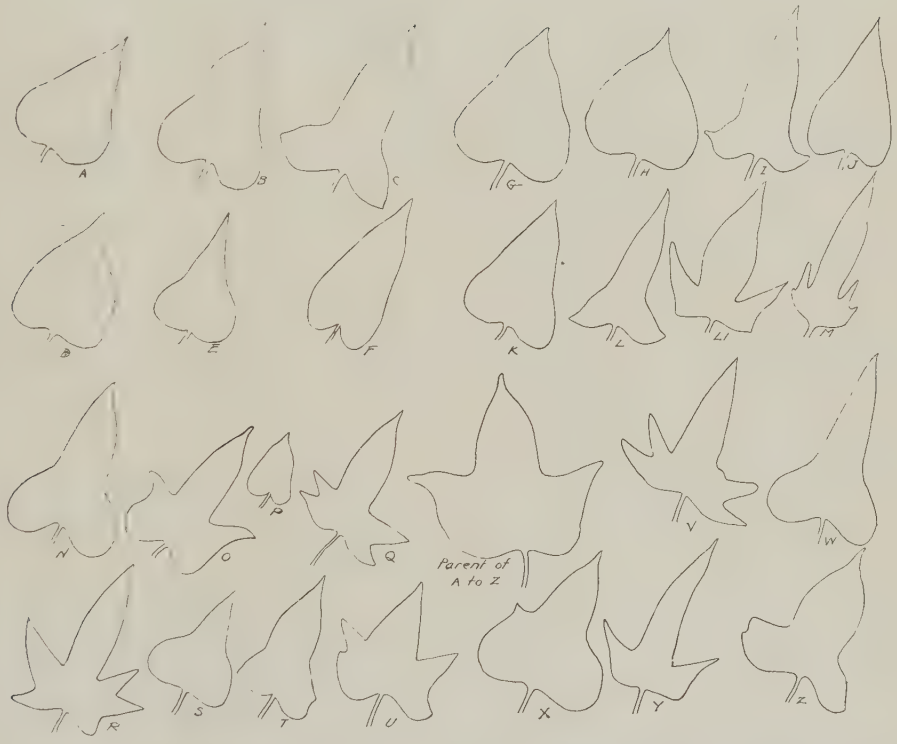

PLATE I. VARIATION IN SHAPE OF LEAF OF 100 SEEDLING SWEET POTATO PLANTS WHICH WERE GROWN FROM SEEDS OF SAMAR BIG YELLOW VARIETY.

6 7

1 2 3 4 5

PLATE II. Details of Reproductive Organs of Sweet Potato

THE POLLINATION OF COCONUT[1]

By Victor C. Aldaba

ONE PLATE

INTRODUCTION

The experiments reported in this paper deal with some facts about the coconut flower and its pollination.

Vista (1) claims that self-pollination in the flowers of coconut is hardly possible, because, before the stigma of the female flowers becomes receptive, all the staminate flowers have already fallen off. In the *Agricultural News*, a fortnightly publication of the Imperial Department of Agriculture for the West Indies (2), the following information about the flowers of the coconut palm may be noted, (the words enclosed in brackets are the author's):

> * * * The yellowish-white flowers, from which the nuts are produced are arranged in spikes, 5 or 6 feet long, [in Laguna variety, about 1½ feet long] branching from a central axis. The branches bear, throughout the greater part of their length, numerous small male flowers and near their base a single female flower [in Laguna variety it may be more than one] much larger than the male. The flowers are enclosed in a tough pointed sheath (known as spathe) 3 or 4 feet in length. The spathe, * * * splits in the lower side.
>
> The flowers give rise to bunches containing twelve to twenty fruits.

Timiriazeff (3) gives the information that people in the markets of Babylon and the Arabs of later days used to sell the male flowers of date palm which were hung by the purchasers among the female flowers to pollinate them; for this plan, it had been noted, was followed by more abundant crops of fruit. The date palm is, according to the same author, like the coconut palm in the point that it has two kinds of flowers; those that bear fruit and the seeds and those that possess only stamens which do not transform themselves into fruit, but are necessary in that they contribute to the formation of fruit in other flowers.

Hunger (4) states that the flowers of coconut are staminate and pistillate. The former are above the latter on the spike. Near the last falling of the male flower the female flower begins to open.

Hunger also states that the coconut is pollinated by insects and wind. The insects are bee hook (*wespen*), bee sting (*begin*), fly (*vliegen*), bug (*kevers*), ant (*mieren*), etc.[2]

The main purpose of the experiments here reported was to study the pollination of coconut. They were carried out in the Division of Genetics in the Department of Agronomy, College of Agriculture, Los Baños, Philippines, during the period from June 11, 1920, to February 18, 1921.

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[1] Thesis presented for graduation from the College of Agriculture, No. 127; Experiment Station contribution, No. 59.

[2] *Cocos nucifera* is written in Dutch. The citation given above is a translation of a part of the book by Albert Thomas You, a student from Java.

MATERIALS AND METHODS

THE TREES USED

Six trees which are located at three different places on the College Farm were used in these experiments. These trees produce nuts of the Laguna type. They are not of the same vigor. They were numbered T1, T2, T3, T4, T5, and T6.

T1, which is about 600 meters from T2, is growing singly in the College Nursery. This tree is seven meters in height. T2, which is as high as T1 but a more vigorous tree, is growing alone near the College Trial Plots. T4, T5, and T6, which are about seven meters high on the average, are in the College Grove which adjoins Mr. Marcos Helbero's plantation where T3 is. These last four trees are about 250 meters from T2. T3 is the most vigorous of the six trees and T6 is the least. Mr. Helbero told the writer that the age of these six trees lies between 19 and 21 years. This statement is in accord with the report of Espino (5) that the age of the coconut trees on the College Farm ten years ago was from 8 to 12 years.

THE FLOWERS

Nature and characteristics of flowers.—The flowers of the coconut are of two kinds, male and female. They are enclosed in a sheath known as a spathe. The sheaths appear in succession from the axil of the leaf. The sheath breaks at the under surface. After splitting, the cluster comes out. At the time of appearance, the cluster is yellowish-white, later it turns to green. At first it is erect, later it droops. An average-sized cluster contains eight thousand or more male flowers and an abundance of pollen.

The ovary of the female flower is enclosed by the perianth at the appearance of the cluster, but after a week or more, it comes out. The stigma of the female flower is small. It remains receptive of pollen grains for two or three days. The male flowers of a cluster drop to the ground before the stigma of the female flower of the same cluster becomes ready for pollination.

Arrangement of parts of flowers.—The coconut is polyandrous and produces its flower along the panicle, varying in length from about 24 to 41 centimeters. Each panicle originates from the central main axis and bears numerous male flowers above and female flowers below. Neither of these two kinds of flowers is perfect. Sometimes, however, male flowers are intermixed with the female. The female flower is larger than the male.

The individual flower is subsessile. The majority of the male flowers on the lower part of the spike are in couples. Each member of a couple represents one type (Plate I, figs. 6-7). Each type has a perianth segment whose margins touch but do not overlap. One individual male flower has six stamens. Each stamen has a coupled anther (Plate I, fig. 8).

The female flower is ovoid. Its perianth segments overlap one another.

Anthesis and life.—The anthesis in the male flowers begins at the appearance of the cluster. The blooming of the flowers in this investigation was found to be more frequent from seven to nine o'clock in the morning than in any other part of the day. Large numbers of male flowers begin to open at six in the morning, and at eight they are fully expanded. Between eight and nine the anther dehisces. Thereafter the anther shrivels and the pollen grains are dislodged. The

dropping of the male flowers then follows. On bright sunny days the anther discharges pollen before the petals are fully expanded. This is common also at noon time and during the afternoon.

A certain number of male flowers open every day. These fall after opening. The daily rate of fall in the observations here reported was determined by catching the flowers in a paper bag hung open below the cluster and counting the catch daily. The fall was as follows:

August	*Flowers*	*August*	*Flowers*
5	58	16	501
7	337	17	443
8	605	18	463
9	659	19	434
10	910	21	206
11	729	22	200
14	1873	23	180
15	1060	24	21

The stigma becomes receptive two or three weeks after the appearance of the cluster. It remains open for two or three days and then begins to turn brown toward the stigmatic end, shrivels and dies.

The ovary may swell a little and acquire a deep green color before dropping to the ground. The majority of the female flowers drop to the ground after the death of the stigma, others develop to form nuts.

The pistil.—The pistils of the two kinds of flowers are very different from one another. That of the male is rudimentary and very much below the anthers, a great number of pollen grains drop on it but there is no development of the nut.

The pistil of the female flower is devoid of style. The stigma which is about three millimeters in diameter is whitish in color before its maturity. It has a triangular suture, which, when it opens, forms an opening almost triangular in shape (Plate I, fig. 10). The opening is a sort of a crack that retains part of the water secreted by the ovary. After two or three days, the secretion ceases and the death of the stigma follows.

The pollen.—In this investigation the pollen grains in an anther were counted under the microscope and found to be 2,607 in number. Since there were 8,706 male flowers in a cluster of average size and 12 individual anthers in a male flower, the number of pollen grains in a cluster were then about 272,358,504. Pollen grains exhibit different forms in dry and wet state. In a perfectly dry state all the pollen grains examined exhibited, approximately, an oblong shape. The longest one found among several that were examined was 18½ microns in length and seven microns in diameter. The shortest was 15 microns long with a diameter of eight microns. When placed in water the pollen grain immediately swells, and in about a minute, it becomes almost spherical. This is true with many pollen grains. The majority of these had a diameter of 13 microns. The pollen grain shows a longitudinal suture under the microscope. In fertile pollen this suture disappears when the grains are moistened. When the pollen grains are allowed to dry, they resume their former oblong shape and exhibit the same suture as before.

The pollen grain has two cell walls, the inner and the outer. The former is thinner than the latter.

The fertile pollen grain, never the abortive one, was found to germinate in sugar solution. In favorable culture medium, the pollen grain germinates in one or two hours.

In all the cultures of pollen grains made, there were found abortive individuals. These were determined by counting under the microscope. The percentage of this kind of pollen grains was found to be from 3 to 33 per cent.

The abortive pollen grains had about two thirds of the length and about one third of the diameter of the fertile ones.

METHOD OF EXPERIMENTS

How the pollen grain is discharged and taken to the stigma.—Observation was made during the life of the flower, particularly when the male flowers were in bloom and the stigma of the female flowers was in a receptive condition.

The flight of pollen grain was determined by putting vaselined or paraffined pieces of glass on the petiole of the leaves of the tree and on the preceding flower, respectively. The visits of insects to the blooming male flower and therefrom to the stigma of the female flower were carefully observed and noted. The bodies of insects were examined for pollen grains.

Determining the normal set of fruits.—"Normal set" is a term used by Tufts (6) in connection with his work on almond pollination, to designate the percentage of fruits which the tree sets under normal conditions when the flowers are pollinated by insects. In this work pollination is not limited to that by insects.

Some clusters were emasculated before the female flowers became receptive. In this way the female flowers were expected to be pollinated with the help of either insect or wind. The other clusters were left undisturbed and allowed to yield nuts naturally.

Artificial cross pollination.—Artificial cross pollination was performed by taking pollen grains from male flowers and placing them on the receptive stigma of female flowers. The cluster, on which this female flower was, was bagged before the latter became receptive. At pollination the bag was temporarily removed but it was put back after the operation. The pollinated female flowers were marked.

Unpollinated female flower.—The yield of nuts under normal and artificial pollination was determined. In these experiments, it is not absolutely known whether all the nuts which developed did so on account of pollination, because the examination for pollen received by the stigma where ovaries developed into nuts was not very thorough and there might have been some that were not pollinated, but which developed into nuts. To find out whether or not unpollinated female flowers develop into nuts, the following experiment was conducted.

The unpollinated female flowers in the clusters used in artificial pollination were counted and are recorded in Table III. Three other clusters were emasculated before their female flowers were ready for pollination. After emasculation, these clusters were bagged.

Determination of the approximate number of pollen grains received by the stigma.—The number of pollen grains received by the stigma was determined at the time the latter was in a receptive condition. It is believed that the insects which visited the flowers carried pollen to them. In the earlier part of the experiment,

counting of pollen was not done for fear the experiments might be destroyed, because there was no way to determine the number except by dissecting the stigma, and this would prevent the formation of nuts. In the latter part of the experiment, the female flowers were no longer required to transform into nuts and hence injury to the stigma was no longer feared.

Vitality test of pollen grains.—In order to determine the vitality of pollen grains, artificial cultures were made in a sugar solution. The solution was placed in Van Tieghem's cells. Pollen grains from the anther of the coconut flowers were transferred into the solution by means of a pointed pin. The culture thus prepared was labeled and placed in a large moist glass chamber that was kept in the dark. Another moist glass chamber was placed in the light.

Numerous experiments were made before the most favorable culture medium for growth was discovered. Cane sugar solutions varying from 2 to 40 per cent in concentration were tried. The best solutions found were those containing 25 and 30 per cent cane sugar.

EXPERIMENTS AND RESULTS

NATURE AND BEHAVIOR OF FLOWER

The clusters of flowers appear in succession from the axil of the leaf approximately on opposite sides of the apex of the trunk of the tree. The appearance was at intervals of from 16 to 32 or more days; that is, a cluster was followed by another after from 16 days to 32 days. It was stated in the beginning of this paper that female flowers become receptive in two or three weeks after the appearance of the cluster, so during the earlier part of the experiment, the cluster below was followed by another at the time or just before its female flowers become receptive. And during the latter part of the experiment (beginning of the dry season in this locality), the succeeding cluster appeared when the stigmas of the cluster below were no longer receptive of pollen.

In artificial pollination, it was found that unpollinated female flowers dropped off the cluster earlier than did the pollinated ones. It is presumed that the same thing happens with the female flowers under natural conditions. Furthermore, vigorous trees shed female flowers later than less vigorous individuals.

POLLINATION

The pollen grains discharged from the anthers are either blown by the wind or they drop to the ground. From the anther a pollen grain may fall on the stigma of a female flower. An insect, on alighting on the male flowers, catches pollen grains on its body and in its visits to the female flower may serve as an agent in coconut pollination.

The amount of pollen which may be carried by the wind from cluster to cluster of a single tree is probably enough to pollinate the female flowers of the cluster below. This was proved by the experiment which follows:

A piece of glass coated with vaseline was put on a cluster which was below another cluster from which pollen was being discharged. After twenty-four hours, 806 pollen grains were found on a 20 square centimeters portion of the glass. The velocity of the wind at this time was about 212.8 miles.

The amount of pollen grains carried by the wind from one tree to another is so little that there is very little chance of cross pollination by this agent. This was proved by another experiment: A piece of glass, 192 square centimeters in area, was placed on one of the petioles of tree, T3. After one week, only 30 pollen

grains were found on the glass. The velocity of the wind during the week was 625.3 miles. As the station where the wind record was made is about 800 meters from tree, T3, this might not be the exact velocity of the wind at the place where the experiment was performed.

Principal insects observed as probable pollinating agents.—The insects observed on the blooming flowers of the coconut represent the three orders, Diptera, Hymenoptera, and Coleoptera. These insects were identified by Professor Woodworth, of the Department of Economic Entomology of this College. The fly is the insect that was always present on the coconut flowers during the day. Some members of the Hymenoptera visited the coconut flowers frequently during morning and afternoon. There was but one member of the Coleoptera that was present at almost any time of the day.

The two common flies that were observed flying from flower to flower were the house fly (*Musca domestica* Linn.) and several species of *Lucilia*. Of the Hymenoptera, the most common were the *Vespaluctuosa* Sauss, *Rhynchiumatrum* Sauss, and *Apis indica* Fabr. The *Trigona biroi* Fr. is another hymenopterous insect that was found, but it is not common.

The first three members of Hymenoptera are believed to be the busy agents in transferring pollen from tree to tree. They also transfer pollen from cluster to cluster of a single tree. *Trigona biroi* may be classified with flies as an active agent in coconut pollination.

The only member of Coleoptera found was *Prionecerus caeruleipennis* Perty. This not being an active insect does not have much to do with pollination.

Relative to the visits of the insects mentioned above, seven receptive stigmas of C7T2, 20 stigmas of C8T3, and 25 stigmas of C10T1 were examined for pollen grains. They were believed to have been pollinated with pollen from other trees because the male flowers in the same cluster dropped to the ground before the female became receptive of pollen. And the succeeding clusters appeared after those stigmas were dead. The examination gave the following results:

No. of stigmas unpollinated	30
No. of stigmas on which more than one pollen grain was found	16
No. of stigmas on which more than five pollen grains were found	1
No. of stigmas on which more than ten pollen grains were found	3
No. of stigmas on which more than 15 pollen grains were found	2

Only two of the stigmas of C8T3 were not pollinated. These two were examined when they were beginning to open. All the others were pollinated with several grains ranging from 3 to 17. Two of those in C7T2 received two pollen grains, each receiving one grain. One received more than 50, while the other four were not pollinated. All those in C10T1, except one that showed one pollen grain, were not pollinated.

This result supports the conclusion that an isolated tree does not bear fruit when the succeeding cluster appears at the time the stigmas of the female flowers below have already passed their receptive condition, and that a tree in a grove under the same conditions bears fruit.

NORMAL SET OF FRUITS

Cluster C3T1 was emasculated at its appearance. C6 of the same tree was cut off before coming out of the spathe. The object was to find out the number of nuts the preceding cluster would yield. C2, C4, C5, and C9 of the same tree were left undisturbed for a similar reason. C2T3, C2T4, and C1 and C2T3 depended on other trees for pollen. C3T3 depended for pollen on both the succeeding cluster on the same tree and of the cluster of other trees.

The number of female flowers was recorded at the beginning of the experiment; and the number of the nuts that developed, at the end.

Result.—In C2T1 only one female flower produced nut. No nut was produced out of 93 female flowers of C5 and C9. C1, C3, and C4 of the same tree and C1, C2, and C3 of tree T3 produced normal sets of fruits.

The clusters, the number of female flowers of which are not given in the table, show only the interval of time of succession of the clusters from the beginning to the end of experiment. These results are given in Table I.

TABLE I.—*Normal set of fruits.*

Designation of clusters and trees.	Date of appearance of cluster.	Date of emasculation or dropping of last male flower.	Date the female flower became receptive.	Date of appearance of succeeding cluster.	Number of female flowers in cluster.	Number of nuts formed.	Percentage formed.
C1T1	June 14	Before July 2	July 2	June 28	46	14	30
C2T1	June 28	Before July 18	July 18	July 18	42	1	2
C3T1	July 18	July 18	Aug. 9	Aug. 5	37	8	22
C4T1	Aug. 5	Aug. 23	Aug. 24	Aug. 25	61	12	20
C5T1	Aug. 25	Sept. 15	Sept. 17	Cut off before appearance	63	0	0
C6T1	Cut off	——	——	——	——	——	——
C7T1	Oct. 10	——	——	——	——	——	——
C8T1	Nov. 4	——	——	——	——	——	——
C9T1	Dec. 5	Jan. 6	Jan. 7	Jan. 26	30	0	0
C10T1	Jan. 26	——	——	——	——	——	——
C2T2	Sept. 21	Oct. 4	Oct. 6	a	20	4	20
C3T2	a	Nov. 5	Nov. 11	Nov. 30	——	——	——
C4T2	Nov. 30	——	——	——	——	——	——
C5T2	Dec. 13	——	Jan. 6	Jan. 17	——	——	——
C6T2	Jan. 17	——	Feb. 8	Feb. 13	——	——	——
C1T3	Aug. 4	Aug. 9	Aug. 20	Aug. 25	23	14	40
C2T3	Aug. 25	Aug. 26	Sept. 17	Sept. 18	33	11	33
C3T3	Sept. 18	Sept. 18	Oct. 12	Oct. 10	34	7	28
C4T3	Oct. 10	Oct. 20	——	——	——	——	——
C5T3	Nov. 3	——	——	——	——	——	——
C6T3	Nov. 30	——	——	——	——	——	——
C7T3	Nov. 1	——	Jan. 21	Jan. 25	——	——	——
C2T4	Nov. 27	Dec. 18	Dec. 19	No succeeding cluster	17	5	29

a The date of appearance of cluster is not known.

ARTIFICIAL CROSS POLLINATION

Ten clusters of different trees were used in this experiment. Several female flowers in five clusters were pollinated with pollen from the other five. For example, six female flowers of C7T1 were pollinated with pollen from several individual male flowers of C5T3, four female flowers of C8T1 were pollinated with pollen from some male flowers of C1T6, etc.

The experiment was closed when nuts had developed.

Result.—C7T1 did not produce any nut while C4T3 produced two nuts out of 12 chances. Two unpollinated female flowers in C4T3 produced nuts. The probable reason for this was that some of the pollen grains dusted upon pollinated female flowers were taken to unpollinated female flowers by the ants that were present during the experiment. The female flowers in C5T3 that were pollinated with pollen from C2T4 did not yield nuts. The other clusters whose female flowers were also cross-pollinated, yielded nuts. The number of pollinated female flowers in the clusters is given in Table II.

TABLE II.—*Artificial cross pollination.*

Number of set.	Designation of cluster and tree.	Date cluster appeared.	Date male flowers removed and the cluster bagged.	Date the female flowers were pollinated.	Pollinizers.	Number of female flowers pollinated.	Number of nuts formed.	Percentage formed.
1	C7T1	Oct. 10	Oct. 10	Nov. 4	C8T1	10	0	0
					C5T3	6	0	0
2	C8T1	Nov. 4	Nov. 22	Nov. 24	C1T6	4	2	50
3	C3T2	a	Nov. 5	Nov. 11	C1T6	7	2	28
4	C4T3	Oct. 10	Oct. 20	Nov. 4	C8T1	6	1	16
					C5T3	6	1	16
5	C5T3	Nov. 3	Nov. 19	Nov. 27	C2T4	4	0	0
6	C1T4	a	Nov. 12	Nov. 27	C1T6	5	3	60
7	C1T5	a	Nov. 29	Dec. 13	C2T6	7	3	43

a Date of appearance not known.

UNPOLLINATED FEMALE FLOWERS

C6T3, C1T6, and C5T2 were emasculated and bagged with cotton cloth before the female flowers became receptive of pollen.

This experiment was ended when all the female flowers in the clusters had dropped to the ground.

Result.—In Table III, the numbers of the female flowers in the clusters experimented with are given. None of these, except the two in C4T3, transformed into nuts. The reason for this has been given.

TABLE III.—*Unpollinated female flowers.*

Number of set.	Designation of clusters and trees.	Date cluster appeared.	Date male flowers removed and cluster bagged.	Date female flowers was receptive.	Number of female flowers unpollinated.	Number of nuts formed.	Percentage of nuts formed.
1	C7T1	Oct. 10	Oct. 10	Nov. 4	18	0	0
2	C8T1	Nov. 4	Nov. 22	Nov. 24	41	0	0
3	C3T2	a	Nov. 5	Nov. 11	11	0	0
4	C4T3	Oct. 10	Oct. 20	Nov. 4	18	2	11
5	C5T3	Nov. 3	Nov. 19	Nov. 27	27	0	0
6	C1T4	a	Nov. 12	Nov. 27	10	0	0
7	C1T5	a	Nov. 29	Dec. 13	14	0	0
8	C6T3	Nov. 30	Dec. 13	Far beyond Dec. 13	30	0	0
9	C1T6	a	Nov. 29	Far beyond Nov. 29	5	0	0
10	C5T2	Dec. 13	Dec. 22	Jan. 6	19	0	0

a Date of appearance not known.

VITALITY OF POLLEN GRAINS

The solution used in the tests for vitality of pollen grains was sterilized by boiling it for fifteen minutes after it was prepared. When cool, pollen grains were put in it. The result of every test was checked by making another culture of the pollen collected at the same time from the same tree in a newly prepared solution. A new solution was used because an old solution does not favor the germination of pollen.

Result.—In a five per cent solution, the culture showed germination after two hours. In 10 per cent and 15 per cent solutions, the cultures were found germinating after one hour. In 20 per cent, 25 per cent, and 30 per cent solutions, pollen grains germinated after two hours. The cultures in 25 per cent and 30 per cent solutions were kept for two days. In the 25 per cent solution, the tube of one of the germinated pollen grains reached the length of about eight times its diameter and one of the pollen grains in the 30 per cent solution reached nine times its diameter. (Plate I, figs. 4-5.) After two days the growth stopped. The culture in the 40 per cent solution did not grow at all. Many trials were made, but all failed to show growth. The solution used in Set 7 soured and the pollen in it did not germinate.

In this experiment the number of days a pollen grain remains viable was also determined. The result is given in Table V. The 20 per cent solution in Set 3 and Set 4 and the other 20 per cent and 25 per cent solutions in Set 5 and Set 6 and the 25 per cent solution in Set 8 soured. All other solutions were newly prepared.

The pollen grains tested for viability were kept in two receptacles. One of these was placed in a desiccator with sulfuric acid and the other was not. The pollen grains kept on the outside maintained the viability longer than those kept in the desiccator. The results in vitality and in viability tests are given in Tables IV and V.

TABLE IV.—*The vitality of pollen.*

Number of sets.	Date pollen was collected.	Date pollen was germinated.	Percentage of solution.	Number of pollen grains tested.	Number germinated.	Percentage of germination.
			per cent			*per cent*
1	Sept. 10	Sept. 10	2	Not counted	Not germinated	
1	Sept. 10	Sept. 10	5	Not counted	Not germinated	
2	Sept. 12	Sept. 12	10	14	1	7
2	Sept. 12	Sept. 12	15	67	3	4
3	Sept. 12	Sept. 12	5	76	50	66
	Sept. 12	Sept. 12	5	81	77	95
	Sept. 12	Sept. 12	10	91	64	70
	Sept. 12	Sept. 12	10	81	56	69
	Sept. 12	Sept. 12	15	78	54	68
	Sept. 12	Sept. 12	15	99	77	78
4	Sept. 17	Sept. 17	5	61	45	74
	Sept. 17	Sept. 17	10			
	Sept. 17	Sept. 17	15	101	91	90
	Sept. 17	Sept. 17	15	82	70	85
	Sept. 17	Sept. 17	20	72	68	95
	Sept. 17	Sept. 17	25	81	68	84
	Sept. 17	Sept. 17	25	79	63	80
5	Oct. 17	Oct. 17	40	161	0	0
6	Oct. 18	Oct. 18	40	151	0	0
7	Oct. 19	Oct. 19	30	100	0	0
	Oct. 19	Oct. 19	40	125	0	0
8	Oct. 22	Oct. 22	30	120	41	34
	Oct. 22	Oct. 22	40	161	0	0

DISCUSSION OF RESULTS

NORMAL SET OF FRUITS

Referring to Table I it will be found that a normal set of fruits in a cluster is dependent upon pollen from male flowers of succeeding clusters and those of another tree. C1T1 yielded 14 nuts out of 46 chances. Its female flowers were pollinated by the succeeding cluster which appeared before its female flowers became receptive. Its male flowers dropped to the ground before C2 appeared. C2 with 42 female flowers yielded only one nut. It is believed that one female flower in C2 was pollinated by pollen from C3 that was emasculated a few hours after its appearance. C3T1 with 37 female flowers yielded 8 nuts and C4 with 61 female flowers of the same tree, 12 nuts. They were pollinated by the clusters which succeeded them. C5T1 did not yield any nuts because C6 of the same tree, that should have succeeded it, was cut off before its appearance. C9 of the same tree produced no nuts because C10 appeared twenty days after its female flowers were in a receptive stage, and the distance between tree T1 and another tree is considerable and the access of insects to tree T1, from another tree, was hardly probable.

TABLE V.—*The viability of pollen.*

Number of set.	Date pollen was collected.	Date pollen germinated.	Percentage of solution.	Where pollen was kept.	Number of pollen grains tested.	Number of pollen grains germinated.	Percentage of germination.
			per cent				*per cent*
1	Sept. 3	Sept. 11	5	outside	51	4	8
	Sept. 3	Sept. 11	5	outside	55	3	5
	Sept. 3	Sept. 17	5	outside	35	0	0
3	Sept. 18	Sept. 18	15	outside	108	91	84
	Sept. 18	Sept. 18	20	outside	96	0	0
	Sept. 18	Sept. 18	25	outside	86	84	98
	Sept. 18	Sept. 18	20	outside	91	0	0
	Sept. 18	Sept. 18	25	outside	46	43	93
4	Sept. 18	Sept. 20	20		58	0	0
	Sept. 18	Sept. 20	25		71	66	93
5	Sept. 18	Sept. 23	20	desiccator	100	0	0
	Sept. 18	Sept. 23	25	desiccator	101	0	0
	Sept. 18	Sept. 23	20	outside	100	0	0
	Sept. 18	Sept. 23	25				
6	Sept. 18	Sept. 24	20	desiccator	150	0	0
	Sept. 18	Sept. 24	25	desiccator	109	0	0
	Sept. 18	Sept. 24	20	outside	100	0	0
	Sept. 18	Sept. 24	25	outside	100	0	0
7	Sept. 24	Oct. 1	20	desiccator	61	0	0
	Sept. 24	Oct. 1	25	desiccator	7	2	28
	Sept. 24	Oct. 1	20	outside	80	27	38
	Sept. 24	Oct. 1	25	outside	46	7	15
8	Sept. 24	Oct. 3	20	outside	47	0	0
	Sept. 24	Oct. 3	25	desiccator	52	0	0
	Sept. 24	Oct. 3	25	desiccator	38	0	0
9	Sept. 24	Oct. 3	25	outside	130	0	0
	Sept. 24	Oct. 3	25	outside	59	0	0
10	Oct. 15	Oct. 15	30	outside	93	85	91
	Oct. 15	Oct. 15	30	outside	156	150	96
	Oct. 15	Oct. 15	25	outside	96	90	93
	Oct. 15	Oct. 15	30	desiccator	52	43	82
	Oct. 15	Oct. 15	30	desiccator	100	94	94
11	Oct. 15	Oct. 17	40	outside	161	0	0
	Oct. 15	Oct. 17	30	desiccator	136	0	0
	Oct. 15	Oct. 17	30	desiccator	125	0	0
	Oct. 15	Oct. 17	30	outside	51	33	64
	Oct. 15	Oct. 17	30	outside	78	52	66
12	Oct. 15	Oct. 18	30	outside			
	Oct. 15	Oct. 18	30	outside	50	3	6

C1 and C2 of T3 yielded many nuts. Their female flowers were pollinated by pollen from the neighboring trees. Female flowers of C3T3 were pollinated by pollen from C4 of the same tree and the other tree.

C2T2 yielded nuts. Its female flowers depended for pollen from the trees in the grove where T4, T5, and T6 are.

ARTIFICIAL CROSS POLLINATION

The fact that a normal set of fruits develop due to the transfer of pollen grains from cluster to cluster and from tree to tree is proved by the results obtained from artificial cross-pollination experiments.

Referring to Table II it may be seen that except in Set 1 and Set 5, nuts were produced by artificial pollination. The writer is not able to explain why pollinated female flowers in Set 1 and Set 5 did not yield nuts.

This result suggests the probability that an isolated tree that produces a cluster the female flowers of which have already passed the receptive stage when the succeeding cluster appears, may be made to bear fruit by artificial pollination.

UNPOLLINATED FEMALE FLOWERS

Table III contains data which prove that unpollinated flowers do not produce fruits. Referring to columns 4 and 5, it will be seen that the female flowers given in the table, except the suspected two female flowers in C4T3 in Set 4, were not pollinated.

GERMINATION OF POLLEN

Vitality of pollen.—Table IV shows the results in several cultures of pollen grains. In these results it is pointed out that pollen grains from different trees do not have the same percentage of vitality. In Set 1 and Set 3, the percentage of vitality of pollen from T1 in 5 per cent, 10 per cent, and 15 per cent solutions was smaller than that of pollen from T2, that was cultured in solutions of the same concentration.

Pollen grains germinate in 5 to 30 per cent sugar solutions. The first 2 per cent cultures in Set 1 showed only sign of tube growth, but the culture in 5 per cent in the same Set 1, gave fair germination. In 5 to 30 per cent solutions, cultures showed vigorous growth with the exception of culture in sour solution. The cultures in 40 per cent solution in Set 5 and Set 6 failed to germinate. Again, other cultures of newly collected pollen were made in newly prepared 30 per cent and 40 per cent solutions. The culture in 30 per cent solution gave 34 percentage germination, but the culture in 40 per cent solution did not grow at all. This is another evidence that pollen grain does not germinate in 40 per cent sugar solution.

Summarizing the discussion, the pollen grain grows in solutions 5 to 30 per cent in concentration. Sour solution does not favor the growth of pollen grains. Pollen from different trees did not show the same percentage of germination. The best growth was found in 25 per cent and 30 per cent solutions.

Viability of pollen.—From Table V it may be noted that pollen grains maintain viability from 2 to 9 days. Set 1 gave in two mounts an average of 6 per cent germination, after 8 days. After fourteen days, as was demonstrated in Set 2, the pollen grain did not possess viability. In Set 4 the viability, as when newly collected, was maintained after two days with a given solution. In Set 7, pollen grains kept both outside and in a desiccator remained viable for six days. But the greater percentage of germination was in favor of those kept in a receptacle outside the desiccator. In Set 9 the viability was not maintained after seven days. In Set 11 the germination was only demonstrated by pollen kept in the receptacle outside.

Sulfuric acid as dehydrating agent is detrimental to the vitality of pollen.

The preceding discussion points out the facts that, (*a*) pollen grain maintains its viability for a number of days; (*b*) pollen grains from different trees do not maintain their viability for the same length of time; (*c*) pollen kept in the receptacle outside a desiccator remains viable longer than that kept inside.

SUMMARY OF CONCLUSIONS

The results of the experiments reported in this paper indicate clearly that the coconut is both close and cross pollinated; that is, a cross is possible between flowers in the same tree or between flowers of different trees.

The majority of male flowers in one cluster begin to open at about six o'clock and dehisce at about eight o'clock in the morning. The female flowers in the same cluster become receptive after two or three weeks from the time of the appearance of the inflorescence.

Insects and wind may serve as agents in pollination. The insects are house fly and several species of *Lucilia* in the order Diptera; *Sarcaphoga* sp., *Vespa luctuosa* Sauss, *Rhynchium atrum* Sauss, *Apis indica* Fabr., and *Trigona biroi* Fr. in Hymenoptera; and *Prionocerus caeruleipennis* Perty in Coleoptera.

The results of this study indicate, further, that artificial pollination in coconut is possible and that unpollinated female flowers do not produce nuts.

There are abundant pollen grains in a cluster of flowers. Pollen grains germinate in 5 to 30 per cent sugar solutions. The pollen remains viable from two to nine days after it is dislodged.

ACKNOWLEDGMENT

The writer is indebted to Dr. N. B. Mendiola, of the Department of Agronomy, under whose direction and advice this work was undertaken; to Prof. H. E. Woodworth of the Department of Economic Entomology, who identified the insects which are here reported; and to Mr. Marcos Helbero, the owner of one of the trees used in this study.

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ILLUSTRATIONS

Plate I

Coconut flowers and germinated pollen grains.

Figs. 1 to 3.—Pollen grains germinated in 25 per cent sugar solution.

Figs. 4 and 5.— Pollen grains germinated in 30 per cent sugar solution.

Figs 6 and 7.—Types of male flowers, closed.

Fig. 8.—A male flower showing anthers.

Fig. 9.—The arrangement of flowers on a newly produced spike.

Fig. 10.—A typical female flower when the stigma is at the receptive stage.

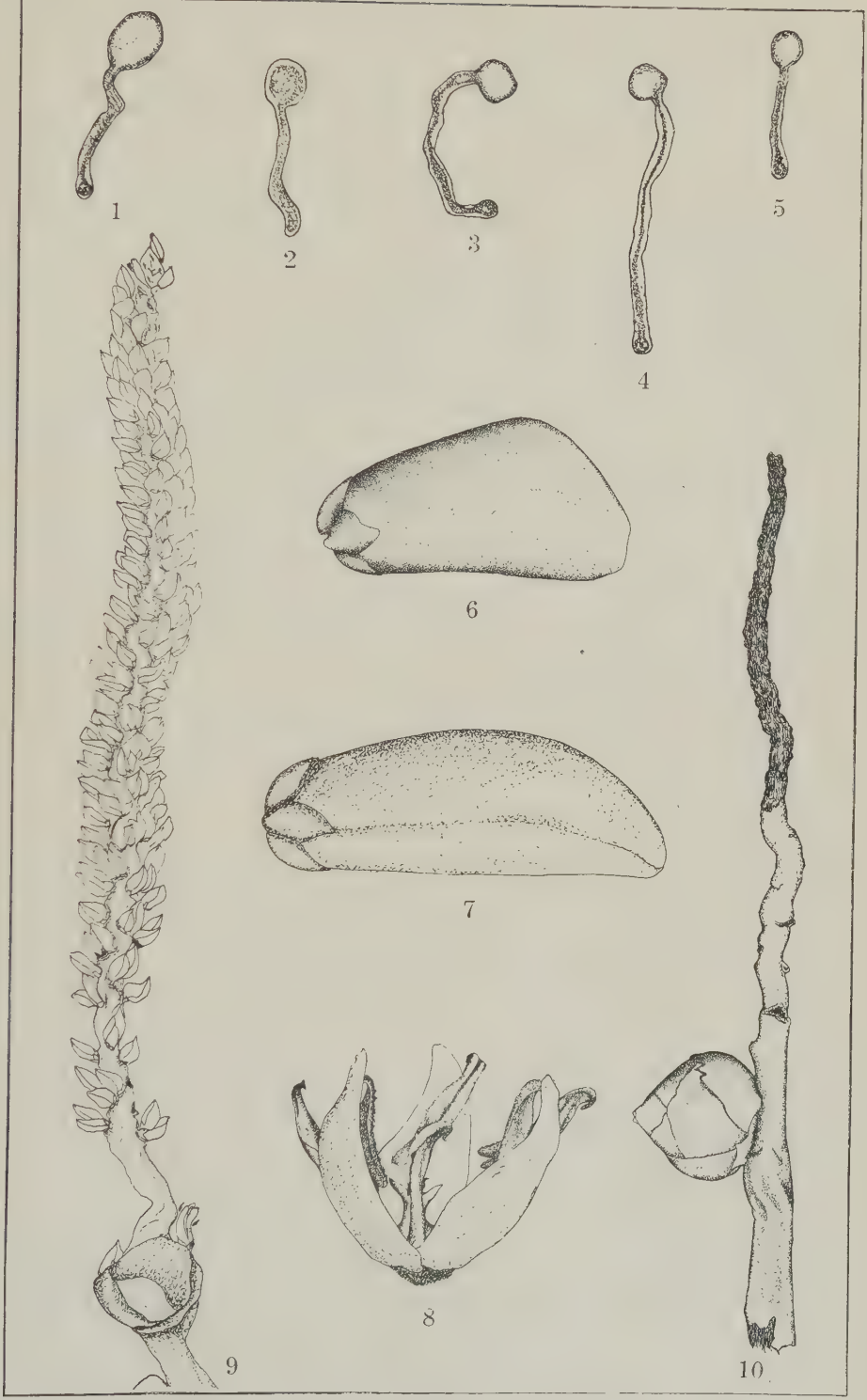

PLATE I. COCONUT FLOWERS AND GERMINATED POLLEN GRAINS.

SUGAR CANE BREEDING IN THE COLLEGE OF AGRICULTURE[1]

By Nemesio B. Mendiola

Of the Department of Agronomy, Division of Genetics

TWELVE PLATES

Sugar cane breeding has already accomplished much for the cane growers. By the production of new superior varieties it has strengthened the position of the sugar cane industry in its competition with the industry of the beet sugar. It has saved the Javanese sugar cane industry from the ruin which once threatened it through the "sereh" disease. It has given new energy to the industry in Louisiana. It has given hope to those countries where the sugar cane industry is still in its infancy.

It is only natural that the attitude of the Philippines towards sugar cane breeding should be inquiring and optimistic. In the Islands, as in other countries where sugar cane is grown, the industry is in bad need of superior, high yielding varieties, and much is expected of cane breeding. Already, the Philippine sugar cane growers are deriving benefit from the breeding work which has been done in other countries, for some of the most promising foreign varieties we now have, such as H-109, are of seedling origin (Plate XII.) But it is expected that the advent of progress in sugar cane growing, due to better varieties may be hastened by work performed in the country.

OBJECT OF THE WORK

The work in cane breeding in the College of Agriculture was started at the suggestion of Dean C. F. Baker, with the aim of obtaining, sooner or later, new varieties superior to those now grown. The varieties now planted are generally poor yielders, both in tonnage and sugar, and are susceptible to sugar cane diseases.

METHOD OF BREEDING FOLLOWED

When facilities are limited, as was the case when this work was started in the College, it is wise to use the simplest method of attack. And this was done. The ideal method is to choose two best varieties, those which bear the characters to be combined, and artificially cross or hybridize them. In this way the parentage of the seedlings is known and the production of better varieties is not a matter of hit-or-miss. But artificial hybridization and a record of parentage consumes an enormous amount of the breeder's time; and, when he is working single-handed, lacking help, he cannot grow the many thousands of seedlings necessary to produce the one or two superior varieties desired.

Because of limited facilities the ideal method was not followed in the beginning of this work,—it is hoped it may be used later—instead, the simple work of growing such seeds as were gathered from varieties which happened to bear fruit in the season, was performed. While simple, the work is known to have produced in other countries some very superior varieties.

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[1]Experiment Station contribution, No. 60.

VARIETIES USED

In the 1919-20 cane fruiting season there were growing on the Experiment Station Farm of the College and in the Trial Plots no less than thirty varieties of sugar cane. Those on the Station Farm were grown side by side and it was not impossible that natural pollination took place between certain individuals. It may be remarked that certain wasps *Allodape mindanaensis*, an anthopila Farm, Ceratinedae, according to Dean Baker, were found visiting the sugar cane flowers at blooming time. Seeds were gathered from all the varieties which fruited and germinated. As record of parentage was not kept, it is not deemed necessary to include in this paper a list of the varieties from which the seeds were gathered.

SELECTION AND GERMINATION OF THE SEEDS

For the benefit of those who may find it necessary to select and germinate sugar cane seeds, the author gives the following directions for doing the work. These directions describe in an indirect way the methods which he, himself, adopted. As will be seen, they do not differ essentially from those used by the sugar cane breeders.

DIRECTIONS

(a) Pick the arrows or flowers from the most desirable stools in the field. Preference should be given to the most vigorous individuals, those which stool heavily and are normally not sprawling, the more erect the better; and, if possible, those free from disease.

(b) Pick the seeds when ripe. The seeds are usually ready for sowing when they begin to shatter easily from the arrows when these are shaken.

If the seeds are still unripe, the selected seed plants must be tagged with a conspicuous label and visited from day to day until the seeds ripen and are collected. If there is plenty of time at the disposal of the worker, it would be desirable to bag the arrows of selected plants before the flowers open, to prevent any possibility of crossing with undesirable plants. This operation is, however, not essential in the work.

(c) If ripe seeds are collected before they are thoroughly dry, they should be placed in a bag and hung up for a few days before germination.

(d) It is preferable to handle seeds of one *variety* separate from those of another.

(e) Pull off the seeds from the arrow and spread them over the surface of the soil.

(f) The soil should be in a box or frame of some sort. The soil in the box or bed should not be less than 10 centimeters deep. It is necessary that all soil for seed beds and seedling boxes be sterilized. This tends to prevent damping off fungi and prevents growth of weeds in seed boxes. If grass seeds are allowed to germinate, it would be difficult to distinguish sugar cane seedlings from the young grass plants. The soil used for germination and for the young plants may be ordinary field soil or one rich in decayed vegetable matter.

(g) Sprinkle with water morning and afternoon, or often enough to keep the soil moist.

(h) The germination boxes should be covered with whitewashed pieces of glass or with glass with old jute sacks on top. Cloth, such as our local "coco crudo," may be used as covering. The seed beds or boxes *should not* be under

shade. Plants should begin to appear in from three to ten days depending upon temperature and moisture conditions. If diseased seedlings should appear, they should be pulled up and burned immediately. (See Plate I).

(i) As the plants grow larger, pull them up and plant them in boxes where the soil is not less than 15 centimeters deep, or in bamboo tubes. (See Plates II and III).

(j) The boxes containing the transplanted plants are not to be covered. However, the plants should be protected from direct sunlight and exposed to the sun only part of the day. When accustomed to light, they may be exposed to direct sunlight continuously if they are watered every morning and afternoon.

(k) Seedlings should be transplanted to the field or potted when the soil depth in the boxes is no longer sufficient for proper development. If potted, the potted plants should again be accustomed to direct sunlight gradually. If transplanted to the field, they should be covered immediately or at transplanting with pieces of banana sheath or with any other protective material, and watered morning and afternoon until the young plants have adapted themselves to the field conditions.

THE FIRST GROUP OF SEEDLINGS OBTAINED

FIRST YEAR TEST

There were obtained in the first year of this work about 10,000 seedlings. Nearly half of these perished before reaching maturity. The group was transplanted to a field back of the Botany Building. This field is not quite adapted for the best cane culture. When the plants were about seven months old, a preliminary observation was made, and published in the *Sugar News* [2].

Results.—It is believed unnecessary to publish the results of the first year test in detail, for, generally, they are unreliable, at least so far as vigor and size of the cane is concerned, for the cane plants which grow direct from the true seeds do not always show the possibilities which are found in the plants grown from their cuttings and tops. It has been commonly observed, for example, that a seedling plant producing stalks which are medium in diameter, produces, if grown from cuttings or tops, what are considered heavy canes. For the same reason, and for purposes of rapid propagation, the cane plants were not analyzed chemically.

The important point which was brought out in this test was the existence of an enormous variability among the seedling plants, (see Plates IV to IX) and that even at the end of the first year there were found several instances of very promising varieties. The field was visited by Mr. H. B. Ross of the Pampanga Sugar Mills and by Mr. Dumas of the Calamba Sugar Estate. Both men were so much interested in the plants that they expressed a desire to be given cuttings for trials in their respective stations. Plates III to VII show some of the typical variations at the age of seven months.

At the mature age, the plant may be divided roughly into three types,—the large, the medium, and the slender. In each group there is a great variability in color, greater than that found in the native and foreign canes now growing in the Philippines.

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[2] Mendiola, N. B. Breeding new varieties at the College of Agriculture. **The Sugar Central and Planters' News 1:** (No. 13) 1-13. 1920.

The large canes are more or less similar in size to the Zambales, the Hambledon Seedling 1900, the Hawaiian seedlings, and other imported heavy canes. The medium seedlings somewhat resemble the native canes in size and the Japanese, or Uba in habit and other characteristics, except they are larger. Most of the slender seedlings are in appearance and other habits like the Uba, or the Japanese canes.

SECOND YEAR TEST

Plant tests, of about 200 selected seedlings, were carried out (1) in this College; (2) in Del Carmen, by the Pampanga Sugar Mills; (3) in Canlubang, by the Central and the Bureau of Agriculture; (4) in Mindoro, by Mr. Hans Doden of the San José Estate; and (5) in Alabang, by the Bureau of Agriculture. An attempt was made to have a test carried out in La Carlota by the Bureau of Agriculture, but this attempt failed because Laguna province was then under quarantine for Fiji disease and cuttings were not allowed shipment to La Carlota. (6) The latest test outside the College is that in Hacienda del Carmen, Pampanga, where the Pampanga Sugar Company has planted a number of the seedling varieties.

Results of test in Del Carmen, Pampanga.—It was Mr. H. B. Ross of the Pampanga Sugar Mills who took the cuttings from the College of Agriculture to Pampanga. Since these cuttings were planted in Del Carmen, Mr. Hind and, lately, Mr. Westley, have been kind enough to keep the College of Agriculture posted as to the progress of the seedling varieties, even sending photographs of the plants. In a letter from Mr. Hind dated January 5, it was learned that the seedlings were doing well. At that time they were about one month old. Last May, when the plants were about six months of age, the writer made a visit to Del Carmen and found some of the seedlings growing as well as the other varieties being tested in the Station. On September 23, 1921, when the plants were about ten months old, in compliance with the author's request, the following report on the experiment was received from Mr. Westley who wrote that the notes were submitted by Mr. Ross.

REPORT ON C. A. SEEDLINGS FROM LOS BAÑOS

Sept, 23, 1921

These canes may be divided into three classes.

(1) Favoring the Uba or Japanese.
(2) Medium sized canes.
(3) Heavy canes.

Those favoring the Uba or Japanese are the following:

C. A. 14809-14819-14820-14807. These more or less resemble the Japanese canes in habit and growth, heavy tops, rapid growth, long jointed, and varying in color from dark green to purple, but apparently only fit for fodder.

In the medium canes may be classed C. A. 12797, although it is really a cane favoring the Uba class, but is much heavier, very long jointed and is an erect vigorous grower, also 12295, which is almost as heavy as the former but has a tendency to shoot out from the eyes or the stool, forming a great many suckers, some of which grow almost as large as some of the Pampanga canes. Also to this class belong C. A. 14285, 13749, 13748.

To the heavy canes belong C. A. 13112, 15723, 15965, 14797, 14598, 15740, 16085, 12735.

Individual Description

C. A. 14285—Slender green cane, heavy top, short nodes, slow growth.

C. A. 13749—Reddish green cane, slender with medium nodes, fair growth.

C. A. 12797—Reddish cane, very long joints, rapid erect grower, the only cane that stood erect after the July 4th typhoon.

C. A. 13748—Yellowish green cane, slender, fairly long nodes, inclined to be recumbent, fair growth.

C. A. 14809—Very slender cane, light purple, long joints, rapid growth, only fit for fodder.

C. A. 14819—Very much like Uba, greenish color, long jointed, heavy top, rapid growth, fodder cane.

C. A. 14820—Very slender purple cane, long jointed, heavy top, rapid growth, fodder cane.

C. A. 14807—Like Uba, dark green, long jointed, recumbent, very heavy top, rapid growth, fodder cane.

C. A. 12295—Heavier than Uba, almost as heavy as 12797, purple, long jointed, very heavy top, rapid growth, shoots badly both from eyes and stool, heavy suckers.

C. A. 13112—Reddish heavy cane, medium joints, good growth, apparently favors Javanese canes.

C. A. 15723—Reddish long jointed cane, heavy, good grower, favors Javanese.

C. A. 15965—Greenish yellow heavy cane, long jointed, slow growth, favors Hawaiian cane as H. 16.

C. A. 14797—Medium purple cane, medium nodes, fair growth, favors Javanese.

C. A. 14598—Heavy reddish green cane, very much like H. 69—short jointed good grower.

C. A. 15740—Medium long jointed cane, somewhat like 13749 but much heavier, fair grower, reddish dark green.

C. A. 16085—Heavy green yellowish cane, long jointed, good grower favors H. 20.

C. A. 12735—Dark purple medium cane, short jointed, fair grower favors Javas.

Only 12797 has been tested,—brix 14.8—sucrose-11.49—purity—77.64—Q. R. 12.30.

So far none have shown any disposition to disease, although 12797 was purposely infected with "Downy Mildew" which however it quickly threw off.

All have shown a good vigorous growth, healthy appearance but the amount of seed was, or is so small that it will take a more extended planting, and several tests to prove their real value.

Results of test at College.—As additional information about C. A. 12797, the writer would add the following notes. The stump of this seedling, remaining after the cuttings for Pampanga Sugar Mills were removed, was transplanted to our Plant Breeding Nursery. From this stump, a ratoon plant was produced which exhibits vigorous growth and a healthy appearance. Plate XI shows a photograph of the ratoon of C. A. 12797, at the age of about ten months. It had then 14 stalks and about two meters of actual cane.

C. A. 12797 may show the advantage of heavy Uba type. The breeding of superior Uba type of canes is quite necessary for, as Mr. Ross pointed out, in Pampanga soils which have been cropped to sugar cane "for centuries" and which does not support the growth of the other cane varieties well, the Uba type of cane promises to be the ideal variety [3].

The other ratoons from transplanted stumps show the following points:

Pedigree No.	*No. of stalks*	*Length of actual cane*
C. A. 15965	5	125 cm.
Unknown	6	100 cm.
Unknown	4	120 cm.

[3] Ross, H. B. Some notes on cane varieties. **Sugar Central and Planters' News 2:** (No. 1) 1-16. 1921.

The plant canes which were grown in the Plant Breeding Nursery were described as follows:

Pedigree No.	*No. of stalks*	*Length of actual cane*
Unknown	9	130 cm.
Unknown	7	100 cm.
Unknown	10	140 cm.

Those grown near the old seedling field were subjected to one transplanting and, as will be seen in Table I, seem to have suffered from it. The observations taken are shown in Table I.

TABLE I.—*Description of individual plants grown from cuttings of seedlings transplanted once.*

C. A. No.	No. of stalks.	Length of actual cane.	Size of stalks.	Growth.	Position of stalks.	Internodes.	Color.
		cm.					
12971	8	62	medium	vigorous	upright	medium	greenish purple
12971	5	70	medium	vigorous	upright	medium	greenish purple
13131	4	73	medium	vigorous	upright	medium	purple
12747	5	63	medium	vigorous	upright	medium	yellowish purple
13132	6	79	medium	vigorous	upright	medium	greenish yellow

In co-operation with the Pathology Department of this College, a test for isolating seedling varieties resistant to Fiji disease was started. Professor Reinking brought supposedly infected soil and also diseased plants from Mindoro on his last trip to that island. The soil and the plants were taken to a place on a hill at the foot of Mount Makiling and placed in holes where the cuttings of the varieties being studied were planted. Ten of the apparently healthy seedling varieties were used. Up to the present time, the disease has not appeared on the seedlings. It is suspected, however, that infection does not take place from the soil to the plant but from plant to plant. In deference to this suspicion, or uncertainty, a much better controlled experiment along this line is being planned.

MR. Francisco Bernardo, a senior student, performed a feeding test of the Uba types under the author's supervision. The test lasted seven weeks. Twenty-two seedling canes of the forage, or Uba type were used. Stalks of each variety were cut, including the leaves, into short pieces and then offered to bullocks, native carabaos, and Indian buffaloes every other day, alternating with the regular ration.

The bullocks refused to eat the material. The Indian buffaloes proved to be good eaters consuming practically all that was offered them. The native carabaos relished the feed less than did the Indian buffaloes.

Of the 22 varieties used, 17 proved quite palatable, as the carabaos did not leave any portion of what was given them. Five varieties were evidently less palatable as feed made of them and offered to the carabaos was not all eaten.

Results of tests in Canlubang.—No detailed notes have so far been taken of the tests in Canlubang. It is very likely, however, that a number of the

seedling varieties planted there will survive the elimination which may be made at the close of the tests. Plate X, fig. 2, shows a fairly promising College seedling variety in Canlubang as compared with Louisiana Striped (fig. 1) in the same field. Louisiana Striped is considered a fast grower in Canlubang.

It is understood that the Bureau of Agriculture is testing a number of the College seedlings in Canlubang for resistance to Fiji and other diseases. The results of this test will, undoubtedly, be published by the Bureau.

As far as the College seedlings which were given to Canlubang direct are concerned, it is known at present, that they have not shown any disposition to Fiji disease, planted as they were near the rows of infected plants.

SECOND GROUP OF SEEDLINGS OBTAINED; PRODUCED IN 1920-21 SEASON

For lack of personnel and because this year we tried to keep record of parentage of seedlings, only a few seedlings were produced. We rejoice, however, in the fact that we were able to obtain seedlings from H-109, Badila and Louisiana Striped. The following is a record of the number of seedlings surviving from among those produced in 1920-21 season:

Pedigree No.	*No. of seedlings*
H-109	3
Badila	75
Louisiana Striped	4
C. A. 15482	34
C. A. 13922	42
C. A. 13725	25
C. A. 14861	10
C. A. 13907	16
C. A. 13917	6
C. A. Unknown	8

CONCLUSIONS THAT MAY BE DRAWN AT PRESENT

1. Different varieties of sugar cane have produced fertile seeds on the College Experiment Station Farm and Trial Plots for the last two fruiting seasons.

2. In the first season, about 10,000 seedlings of sugar cane were raised and in the second, 223.

3. After the first year test of the first group about 200 seedling varieties were saved for the second year tests. These are now being carried out in the College of Agriculture; in Mindoro; in two localities in Pampanga; in Alabang, Rizal; and in Canlubang, Laguna. The tests include resistance to Fiji disease.

ACKNOWLEDGEMENT

I am greatly indebted for assistance in this work to Mr. Crispin Villanueva, who was formerly an assistant in Plant Breeding in this College, and to my two graduate assistants at the present time, Mr. Juan Unite and Mr. José Capinpin. Much of the intelligent labor involved in this work was performed by my 1920-21 Plant Breeding class.

To those men outside the College of Agriculture who have volunteered or agreed to carry out tests of the College seedlings, the College of Agriculture is under deep obligations.

ILLUSTRATIONS

PLATE I

Sugar cane seed germination flats covered with glass and cloth.

PLATE II

Young cane seedlings pricked into seed flats and bamboo tubes, awaiting transplanting age.

PLATE III

Nearer view of cane seedlings pricked in seed flats.

PLATE IV

A group of cane seedlings showing variability in height.

PLATE V

A group of very vigorous cane seedlings.

PLATE VI

Fig. 1.—C. A. 1401 resisted force of typhoon.
Fig. 2.—C. A. 14898. Reclining position is due to effect of typhoon.

PLATE VII

Fig. 1.—C. A. 14815, a promising forage cane. Note spreading growth habit.
Fig. 2.—C. A. 15895, a slow growing cane. Probably not a tall type.

PLATE VIII

A group of seedlings, including an individual of probable Japanese cane parentage, showing variation and stooling habit.

PLATE IX

Fig. 1.—C. A. 16618 showing a very poor stooling habit.
Fig. 2.—C. A. 15578, a promising forage cane showing close growth habit. Contrast with C. A. 14815, Plate VII, Fig. 1.

PLATE X

Fig. 1.—Louisiana Striped cane, five months old, in Canlubang, Laguna.
Fig. 2.—College of Agriculture seedling canes, seven months old, in Canlubang, Laguna.

PLATE XI

C. A. 12797. First ratoon from transplanted seedling stump.

PLATE XII

H 109 cane, six months old, in Canlubang, Laguna.

Plates I to X inclusive and XII are reprinted by courtesy of the *Sugar Central and Planters News*.

PLATE I. SUGAR CANE SEED GERMINATION FLATS.

PLATE II. YOUNG CANE SEEDLINGS PRICKED INTO SEED FLATS AND BAMBOO TUBES, AWAITING TRANSPLANTING AGE.

PLATE III. NEARER VIEW OF CANE SEEDLINGS PRICKED IN SEED FLATS.

PLATE IV. A GROUP OF SEEDLINGS SHOWING VARIABILITY IN HEIGHT.

PLATE V. A GROUP OF VERY VIGOROUS CANE SEEDLINGS.

Fig. 1. C. A. 1401 resisted force of typhoon.

Fig. 2. C. A. 14898. Reclining position due to effect of typhoon.

PLATE VI.

Fig. 1. C. A. 14815, a promising forage cane. Note spreading growth habit.

Fig. 2. C. A. 15895, a slow growing cane. Probably not a tall type.

PLATE VII.

PLATE VIII. A GROUP OF SEEDLINGS, INCLUDING AN INDIVIDUAL OF PROBABLE JAPANESE PARENTAGE, SHOWING VARIATION AND STOOLING HABIT.

Fig. 1. C. A. 16618 showing a very poor stooling habit.

Fig. 2. C. A. 15578, a promising forage cane showing close growth habit. Contrast with C. A. 14815, Plate VII, Fig. 1.

PLATE IX.

Fig. 1. Louisiana Striped cane, five months old, in Canlubang, Laguna.

Fig. 2. C. A. seedling canes, seven months old, in Canlubang, Laguna.

PLATE X.

PLATE XI. C. A. 12797. FIRST RATOON FROM TRANSPLANTED SEEDLING STUMP.

PLATE XII. H 109 CANE, SIX MONTHS OLD, IN CANLUBANG, LAGUNA.

COMPARATIVE TESTS OF RICE SEEDS FROM THE PRINCIPAL AND POOREST CULMS IN INDIVIDUAL PLANTS[1]

By Juan O. Unite

INTRODUCTION

In the Philippines, it has been suspected that in each rice plant the seeds on the main culm[2] are better yielders than those produced on any of the secondary culms.

The supposition that seeds on different culms of a rice plant are different in value appears to be in line with the theory, as cited by Babcock (1), of Frederic F. Hallet, the celebrated English breeder of cereals, that there is one best spike that contains the best grains on a wheat plant.

Newman (2) points out that in the amelioration of seeds at the Swedish seed station in Svalöf, and before the introduction of selection by pedigree cultures, the practice was to take the seed from the heads or panicles of only the main stems of each chosen plant. This practice, according to him, was based on the principle that such heads or panicles offered greater possibilities than did those borne on the secondary and less perfectly developed culms.

So far as the writer knows, the relative yield value of seeds on the different culms of individual rice plants has not, as yet, been demonstrated in the Philippines or in other rice growing countries. A test of this question is of practical importance to rice growers and has an important bearing on the question of seed. If it be true that seeds on the main culm are better producers than those on other culms, increased yield could easily be obtained as it would not be hard to pick out the principal heads of individual plants for seed purposes.

The object of the present work was to determine whether increased yield is obtained by planting seeds from only the principal culms of the rice plant.

This work was conducted at the College of Agriculture, University of the Philippines, between October, 1919, and February, 1921.

MATERIALS AND METHODS

VARIETIES USED

The varieties used in this work were Putyucanon, bearing the College Number 4497 F_4, and Tiniaong. These varieties are beardless and may be grown either under upland or lowland conditions.

SECURING THE PARENT PLANTS

One hundred stools[3] of Putyucanon were taken from the field cultures of Anselmo Labrador, a member of the Class 1920, just before harvesting in October, 1919, and one hundred stools of Tiniaong were obtained, during harvest time in 1920, from the field of a farmer in the barrio of Anos, Los Baños.

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[1] Thesis presented for graduation from the College of Agriculture, No. 128; Experiment Station contribution, No. 61.

[2] Culm—One of the shoots which constitute a rice plant.

[3] Stool—A cluster of culms, constituting a plant.

LABORATORY STUDY OF PARENT PLANTS

The plants were pulled out of the soil, kept separately, and brought to the laboratory for further study. In the laboratory they were numbered and each plant was studied for the number of culms and for the number of bearing and non-bearing culms. The principal and poorest culms of each plant were then selected. The height, length of panicle, number of grains per panicle including missing, and the weight of 100 unhulled grains of the principal and poorest culms were determined.

TABLE I.—*Frequency distribution of the height of culm.*

Class value.	Putyucanon.		Tiniaong.	
	Frequency.		Frequency.	
	Principal culm.	Poorest culm.	Principal culm.	Poorest culm.
cm.				
30	——	1	——	1
35	——	1	——	1
40	——	0	——	3
45	——	0	——	5
50	——	0	——	5
55	——	1	——	14
60	——	0	——	6
65	——	0	1	9
70	——	2	3	9
75	——	1	2	9
80	——	1	6	11
85	——	4	6	1
90	——	2	21	0
95	——	2	12	1
100	——	7	16	0
105	——	12	4	——
110	——	9	2	——
115	2	14	1	——
120	1	11	1	——
125	3	14	——	——
130	6	10	——	——
135	8	4	——	——
140	20	3	——	——
145	29	1	——	——
150	13	——	——	——
155	13	——	——	——
160	5	——	——	——
Total	100	100	75	75
Mean and probable error.	143.55 ±0.61 cm.	111.60 ±1.34 cm.	132.27 ±0.70 cm.	103.20 ±0.99 cm.

DISTINGUISHING CHARACTERISTICS OF THE PRINCIPAL AND POOREST CULMS

From a study of the data obtained[4] it was very evident that the principal culm is different from the poorest culm in many respects. The principal culm is usually the longest among the individual culms of a plant, and bears the longest and best filled head. The poorest culm is the shortest and bears the shortest and only partly filled head. Despite these differences the weight of the individual grains of each is practically the same. The average weight of 100 unhulled grains of the principal culm is practically the same as that of 100 unhulled grains of the poorest.

The frequency distributions of the data obtained are shown in Tables I, II, III, and IV.

TABLE II.—*Frequency distribution of the length of panicle.*

Class value.	Putyucanon.		Tiniaong.	
	Frequency.		Frequency.	
	Principal culm.	Poorest culm.	Principal culm.	Poorest culm.
cm.				
12-13	——	——	——	1
14-15	——	1	——	8
16-17	——	4	——	15
18-19	——	7	2	33
20-21	1	9	22	14
22-23	0	17	30	3
24-25	2	24	19	1
26-27	14	24	1	0
28-29	28	10	1	0
30-31	22	3	——	——
32-33	21	1	——	——
34-35	9	——	——	——
36-37	1	——	——	——
38-39	2	——	——	——
Total	100	100	75	75
Mean and probable error.	30.16 ±0.19 cm.	24.10 ±0.24 cm.	22.44 ±0.14 cm.	18.21 ±0.16 cm.

[4] These and other data obtained in this work are on file in tabulated form in College of Agriculture. Copies will be furnished on application. Limited space prevents their appearance in the **Philippine Agriculturist.**

TABLE III.—*Frequency distribution of the number of grains in the culm including missing.*

Class value.	Putyucanon.		Tiniaong.	
	Frequency.		Frequency.	
	Principal culm.	Poorest culm.	Principal culm.	Poorest culm.
No. of grains				
1- 20	——	1	——	1
21- 40	——	1	——	14
41- 60	——	2	1	17
61- 80	——	11	2	27
81-100	——	5	6	11
101-120	——	18	16	3
121-140	5	16	18	2
141-160	2	4	18	——
161-180	7	4	10	——
181-200	10	1	4	——
201-220	17	1	——	——
221-240	9	——	——	——
241-260	6	——	——	——
261-280	3	——	——	——
281-300	2	——	——	——
301-320	0	——	——	——
321-340	3	——	——	——
Total	64	64	75	75
Mean and probable error.	212.38 ±3.85 grains.	111.44 ±3.07 grains.	133.70 ±2.29 grains.	64.37 ±1.90 grains.

EXPERIMENTS AND RESULTS

CULTURES INVOLVED

In the test of the seeds of the principal and poorest culms, cultures were conducted in cans and in plots. The seeds of the parent plants were planted in cans, while those of the progeny were planted in plots. There were two sets of can cultures and one of plot cultures. The first set of can cultures was undertaken by Doctor Mendiola of the Division of Genetics between November 5, 1919, and March 3, 1920. The second set and the plot cultures were undertaken by the writer between July 17, 1920, and February 3, 1921.

CAN CULTURES, FIRST SET

One hundred empty petroleum cans were cleaned and filled with about equal amounts of soil. To insure a uniform effect of soil conditions, the soil was taken from one portion of a field and was thoroughly mixed before putting it in the cans.

On November 5, 1919, these 100 cans were planted to Putyucanon. Each can contained four hills; two hills were planted with seeds from the principal culm and the other two with seeds from the poorest. Three or four grains were planted in a hill. The grains from each culm occupied two diagonally opposite corners of the can. The hills were numbered and labeled as to the number of parent plant and the kind of parent culm. For example, the two hills occupied by seeds from

the main culm of parent plant No. 1 were labeled B-1a and B-1b and the hills occupied by the grains from the poorest culm, P-1a and P-1b. The letters "B" and "P" mean "Principal" and "Poorest", respectively. When the plants were about 15 centimeters high they were thinned to one plant to a hill. During the progress of the experiment, a point was made of giving the plants treatment as nearly alike as possible.

On March 3, 1920, the plants were harvested and the panicles of each plant placed in an envelope. The yield of each plant was determined by weighing the grains after drying.

TABLE IV.—*Frequency distribution of the weight of 100 unhulled grains.*

Class value.	Putyucanon.		Tiniaong.	
	Frequency.		Frequency.	
	Principal culm.	Poorest culm.	Principal culm.	Poorest culm.
grams				
2.15-2.20	——	——	——	1
2.25-2.30	——	——	4	2
2.35-2.40	——	——	3	6
2.45-2.50	0	2	8	17
2.55-2.60	1	1	17	7
2.65-2.70	1	3	15	12
2.75-2.80	0	3	5	5
2.85-2.90	0	1	1	1
2.95-3.00	2	3	1	3
3.05-3.10	4	5	——	——
3.15-3.20	11	10	——	——
3.25-3.30	10	8	——	——
3.35-3.40	9	6	——	——
3.45-3.50	6	3	——	——
3.55-3.60	4	2	——	——
3.65-3.70	1	2	——	——
3.75-3.80	0	0	——	——
3.85-3.90	0	1	——	——
3.95-4.00	1	0	——	——
Total	50	50	54	54
Mean and probable error.	3.29 ±0.07 grams.	3.17 ±0.09 grams.	2.61 ±0.04 grams.	2.58 ±0.06 grams.

CAN CULTURES, SECOND SET

The experiment with variety, Putyucanon was duplicated, beginning October 22, 1920, with the variety, Tiniaong. By "principal" culm in this set is meant the longest. It is of course not always true that the principal culm is the longest. Indeed, in an examination of 70 rice plants, it was found, in nine cases, that the principal culm was not the longest. However, neither was the principal culm the shortest. It was the intention of the writer to use the same number of plants as in the Putyucanon experiment, but because of the shortage at the time of empty petroleum cans, only seventy-five parent plants of Tiniaong were

handled. In this set the same method of planting and treatment of the plants, as used in the first set, was followed. Check seeds were also planted. The seeds for check were obtained from the mixed seeds of the parent plants after the panicles of the longest and poorest culms had been separated.

On February 3, 1921, the plants of the second set were harvested and studied.

PLOT CULTURES

The seeds of the progeny of the 100 parent plants in the first set of can cultures were planted in plots.

The land used was 70 meters long and 12½ meters wide and was a portion of the rice breeding field of the Division of Genetics on the Experiment Station Farm. The whole field was plowed with a disc plow pulled by a tractor. After the necessary preparation of the field had been completed, furrows about sixty centimeters apart were made by using a furrower drawn by a bullock. The field was then divided into ten equal plots each of which was again subdivided into two equal smaller plots.

Planting was done on July 17, 1920. The seeds were drilled in the furrows, dropping them a few centimeters apart. The seeds of the principal culm parentage occupied one sub-plot of each of the main plots, while the seeds of the poorest culm parentage occupied the other. The sub-plots planted with seeds of one kind alternated with those planted with seeds of the other. The following diagram illustrates the arrangement of the plots.

Plot 1	
Progeny of principal culms	Progeny of poorest culms
Plot 2	
Progeny of poorest culms	Progeny of principal culms

The object of distributing the plots planted with one kind of seed throughout the field was to minimize the experimental error in yield brought about by possible non-uniformity of soil conditions.

At the beginning of the month of December, 1920, the plot cultures were harvested. The panicles of the plants in each sub-plot were put together in a paper bag, threshed, and the grains weighed after drying. The number of plants in each sub-plot was also recorded.

Table V shows the results of these cultures.

TABLE V.—*Average yield per plant of Putyucanon in plot cultures.*

Plot number.	Principal culm.			Poorest culm.		
	Total harvest.	Total number of plants in the plot.	Average yield per plant.	Total harvest.	Total number of plants in the plot.	Average yield per plant.
	grams		*grams*	*grams*		*grams*
1	375.50	122	3.08	553.53	205	2.70
2	186.69	44	4.24	505.38	106	4.77
3	371.41	126	2.94	240.02	105	2.30
4	509.70	119	4.28	399.48	88	4.53
5	776.82	168	4.62	276.48	67	4.13
6	277.11	77	3.60	280.75	70	4.01
7	542.80	198	2.74	567.65	203	2.80
8	577.64	148	3.90	452.99	126	3.59
9	1145.83	254	4.51	461.61	99	4.66
10	571.15	171	3.34	584.25	153	3.82
Total			37.25			37.31
Average			3.72			3.73
Probable error of the average			±0.136			±0.173

DISCUSSION OF RESULTS

CAN CULTURES, FIRST SET

It was noted that certain individual progeny of the principal culms exceeded certain individual progeny of the poorest culms in yield, height, and number of bearing culms. But it was also seen that certain progeny of the poorest culms exceeded those of the best culms in the same respects. When the average, however, was considered it was found that the plants of the principal culm parentage exceeded those of the poorest culm parentage in yield, height, and number of bearing culms by 0.14±0.254 gram, 0.8±1.079 centimeters, and 0.04±0.637 bearing culm respectively. These differences, however, it must be emphasized, are insignificant.

At this point it is important to consider the average height, length of panicles, and the number of grains per panicle of the parent culms. The average height, length of panicles, and the number of grains per panicle of the principal culm parents were 143.59 centimeters, 30.23 centimeters, and 135.74 grains respectively, while those of the poorest culm parents were 111.87 centimeters, 24.14 centimeters, and 72.01 grains respectively. There was a difference in height of culms of 31.72 centimeters, in length of panicles of 6.09 centimeters, and in number of grains per panicles of 63.73 grains in favor of the principal culmed parents. If external characters be correlated to yield, then the progeny of the principal culmed parents should give significantly more yield than the progeny of the poor culmed parents. Table VI shows no significant difference in yield, height of plants, and number of bearing culms.

TABLE VI.—*Summary of results of first and second can cultures, and of plot cultures.*

Characters compared.	Putyucanon					
	Difference in yield.	Value of difference.	Difference in height.	Value of difference.	Difference in number of bearing culms.	Value of difference.
	grams		*centimeters*			
Principal culm *vs.* poorest culm	0.14±0.254	Insignificant	0.8±1.079	Insignificant	0.04±0.637	Insignificant
Principal culm *vs.* check						
Poorest culm *vs.* check						
Principal culm *vs.* poorest culm (plot cultures)	0.01±0.22	Insignificant				

Characters compared.	Tiniaong					
	Difference in yield.	Value of difference.	Difference in height.	Value of difference.	Difference in number of bearing culms.	Value of difference.
	grams		*centimeters*			
Principal culm *vs.* poorest culm	0.09±0.165	Insignificant	0.8±0.806	Insignificant	0.22±0.596	Insignificant
Principal culm *vs.* check	0.30±0.177	Insignificant	—1.1±0.889	Insignificant	0.14±0.787	Insignificant
Poorest culm *vs.* check	0.21±0.183	Insignificant	—1.9±0.943	Insignificant	0.08±0.781	Insignificant
Principal culm *vs.* poorest culm (plot cultures)						

CAN CULTURES, SECOND SET

It is to be recalled that in this culture the seeds from the "longest culm" in each plant were considered the seeds from the principal culm. But, as has been explained, there are a few exceptions to this supposition. However, it is

believed that even if the seeds did not all come from the principal culms, the culture as a whole may be considered as a comparative test of the seeds from the principal and poorest culms.

The results of the test with Tiniaong confirmed those obtained from the test with Putyucanon. The progeny of the longest culms outyielded those of the poorest culms and check by 0.09±0.165 gram and 0.30±0.177 gram respectively. The progeny of the poorest culms gave a higher average yield than the check, the difference being 0.21±0.183 gram in favor of the plants of the poorest culm parentage. In height the progeny of the principal and poorest culms were exceeded by the check by 1.1±0.889 centimeters and 1.9±0.943 centimeters, respectively. The differences in the number of bearing culms between the progeny of the longest culms and those of the poorest culms and check were 0.22±0.596 and 0.14±0.787 bearing culm, respectively, that of the progeny of the poorest culms and the check was 0.08±0.781 bearing culm. Again, it must be borne in mind, no one of these differences is significant.

PLOT CULTURES

Had it not been for the poor percentage of germination of the seeds, a greater number of plants than Table V shows would have been harvested. The writer is inclined to believe that the failure of a number of seeds to germinate was due to unfavorable soil conditions which resulted from the effect of continuous heavy rains and strong winds that prevailed for about a month just after planting. The soil became hard and the seeds became buried deep.

The results of these experiments further confirm what is shown by the results of can cultures, for the seeds of the progeny of the principal culm parentage were no better in yield value than those of the progeny of the poorest culm parentage. The plants of the poorest culm parentage gave a higher average yield than those of the principal culm parentage. The difference, which is insignificant, is 0.01±0.220 gram in favor of the plants of the poorest culm parentage.

As far as the present results show, increased yield may not be expected by planting seeds only from the panicles of the principal culms or the longest culms which are generally the principal culms also in individual rice plants. In so far as inheritance of yield is concerned it would appear that seeds from the poorest culm produce plants that would yield as much as those produced by any of the other culms on that same plant.

SUMMARY OF CONCLUSIONS

Plants from seeds of the principal, or longest and the poorest culm of individual rice plants were found in two generations to have equal yield values.

ACKNOWLEDGMENT

The writer acknowledges his indebtedness to Dr. Nemesio B. Mendiola of the Department of Agronomy for his valuable suggestions and advice during the progress of this work.

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TWO SERIOUS PLANT DISEASES NEW TO THE PHILIPPINES

By Colin G. Welles
Of the Department of Plant Pathology

COTTON ANTHRACNOSE

That very serious disease of cotton known as anthracnose has recently been found on cotton bolls at the College of Agriculture, Los Baños.

The loss due to this disease is great and measures should be taken by all cotton growers to keep diseased seeds or plants from their plantations. The disease has not hitherto been reported from any portion of the Philippines, so careful seed selection and strict quarantine of the College cotton may prevent further spread.

The symptoms of anthracnose are as follows: The bolls first develop small reddish or reddish-brown spots, with a slight shrinking of the tissue in the center. The spots gradually enlarge and the centers turn black, while the rims remain reddish. Lesions may coalesce and form large irregular diseased areas which, in many cases, involve a large portion of the surface of the boll.

If the bolls are attacked when young, they may be peculiarly deformed or may crack open, exposing the fiber to the weather and further destruction by disease.

When the disease develops from the seed, the stems frequently become parasitized at, or slightly below, the surface of the soil. The plants in such an attack collapse even before the lesions have developed to any great extent.

The stems frequently develop lesions through injury or due to a general weakened condition. These lesions appear similar to those on the bolls.

CAUSAL ORGANISM

The fungus responsible for this trouble is known as *Glomeralla gossypii* (Southw.) Edg. or *Collectotrichum gossypii* Southw., the latter being the imperfect stage which alone has been found in the Philippines.

The organism fruits in a loose stroma which breaks through the epidermis. Conidia are borne mainly on short hyaline conidiophores and less frequently are formed on the long setae.

The spores are oblong, often slightly pointed at the base, and vacuoles are frequently present.

The spores are probably disseminated by wind and rain.

CONTROL

The organism remains virulent on seeds and on dead tissue in the soil for long periods and control is, therefore, not easily effected. Cotton should not be grown indefinitely on any soil if the disease is present. This practice allows an accumulation of diseased material and results in continuous infection. Crop rotation should be practiced as it is with other agricultural crops. The removal and burning of the plants after harvest will lessen the chances for infection and the selection of seed from healthy bolls will reduce the stem disease to a great extent.

LEAF SPOT OF SWEET POTATO

A very serious *Cercospora* leaf spot of sweet potato was reported by Reinking (1) from China. He described the disease as very destructive and suggested that all manner of precaution be taken to keep it from entering the Philippines.

Observations have revealed this disease on sweet potatoes at the College of Agriculture and measures should be taken to stop its spread to other portions of the Philippines where it is not present.

SYMPTOMS

The disease is readily recognized by the black spots scattered profusely over the leaves and penetrating to the lower surface.

CAUSAL ORGANISM

The causal organism of this disease is *Cercospora batatae* Zimm. The spores and conidiophores are typical of *Cercospora* and by measurement have been identified as those of the above named fungus.

CONTROL

A possible control is crop rotation as suggested by Reinking, and the horticultural practice of planting during the drier seasons of the year should be of great help.

LITERATURE CITED

(1) Reinking, Otto A. Diseases of economic plants in southern China. **Philippine Agriculturist 8: 131.** 1919.

ABSTRACTS[1]

Variety test of cassava based on production, PEDRO L. SISON (*Thesis presented for graduation from the College of Agriculture, No. 129; Experiment Station contribution, No. 62*).—The experiment reported by Mr. Sison was carried out with the object of isolating the best varieties of cassava as judged from their yielding capacity. Ten varieties of cassava were studied; the description of each is given in the thesis.

The ten varieties were planted on properly prepared land. "Each variety occupied five rows numbering at least three hundred and fifty cuttings." In planting these different varieties, however, no check variety to reveal any variation due to soil was used.

Records on yield of each variety at the ages of 10, 11, and 12 months were made. The yield of each variety was computed by taking the actual yield of 100 plants and then figuring out the yield per hectare, assuming there were 10,000 plants on a hectare.

The author observed no severe disease of cassava. The most destructive enemy was the wild hog.

Tests on cooking qualities and the other purposes to which the varieties were best suited, were made by the author.

Noteworthy data on yield of different varieties at different ages are recorded in Table I in the thesis. A summary of the table is here given:

College number.	Variety name.	Yield per hectare.		
		10 months.	11 months.	12 months.
		kg.	*kg.*	*kg.*
645	Kapo Colorado or Red	7,146	9,960	10,840
7780	White Smooth Intermediate	8,640	12,360	12,300
6222	Angular	9,280	12,940	13,860
638	Rough Intermediate	10,640	13,280	14,320
644	Kapo White or Green	11,260	11,740	15,220
3899	Manis	12,980	15,120	16,140
3900	Sipin Valenca	18,320	20,320	20,970
3897	Sipin Mangi	19,200	22,620	35,700
3898	Mandioca Basiorao	36,060	37,780	38,820
3896	Mandioca sao Pedro treto	27,880	37,180	38,500

[1] Abstracts prepared as part of required theme work in English 4, College of Agriculture.

The author concluded that varieties, Sipin Mangi, Mandioca Basiorao, and Mandioca sao Pedro treto seemed to be the best yielders, their yields being more than 35,000 kilograms per hectare at the age of 12 months. The yields, however, varied with the ages at which harvests were made, and recommendation to the effect that further investigation as to the age at which the highest possible yield can be secured from these selected varieties was made by the author.

From tests and observations on varietal characteristics, the varieties were classified as follows:

(a) Sweet, less fibrous and fine-textured—Kapo White or Green, Mandioca Basiorao, Sipin Valenca, and Sipin Mangi.

(b) Good yielders and at the same time, sweet, less fibrous, and fine-textured—Sipin Valenca, Sipin Mangi, and Mandioca Basiorao.

(c) Best materials for commercial manufacture of starch and flour—Sipin Valenca, Mandioca Basiorao, and Mandioca sao Pedro treto

(d) Good for boiling—Sipin Valenca, Mandioca Basiorao, Kapo White or Green, and Sipin Mangi.

(e) Most bitter variety—Mandioca sao Pedro treto.

Abstract by José M. Capinpin.

Variety test of upland rice, Julian A. Morada (*Thesis presented for graduation from the College of Agriculture, No. 130; Experiment Station contribution No. 63.*—The author performed this experiment with the aim of determining the comparative yields of the following sixteen varieties of upland rice: Binicol, Binuncaue, Binundoc, Benguet, Bulandi, Guluyang pula, Inintiw, Kinagaykay, Kinanda, Maliro, Pinursigui, Putyocanon, Quinistila, Sinacoban, Sanglay puti, and Tiniaong.

The seeds of the sixteen varieties were planted in furrows made sixty centimeters apart in the prepared twenty-three equal plots. Each plot had an area of forty square meters and the distance between the hills was twenty centimeters. Eight of these plots were for the checks. The rice plots were cultivated two times when the plants were at the ages of seventeen days and forty days. Harvesting was done by hand with the aid of a knife called *pangani*.

Rice borer was an insect pest observed in all varieties.

The author draws the following conclusions:

1. An increase of 128 per cent is possible by using the high yielding varieties.

2. Binuncaue, Quinastila, Kinanda, and Pinursigui are superior to other varieties studied. Kinanda leads as to the size of grains, cooking quality, palatability and earliness.

3. Through selection of superior varieties and fertilization of the soil combined, an increase of 282 per cent by weight may be possible.

4. There is a possibility of obtaining an increase of 225 per cent by weight through fertilization.

The useful data gathered from the thesis may be briefly summarized in the following table:

Variety names.	No. days to appear above grouud.	No. days to head.	Age in days of maturity.	Yield per hectare.	Yield per hectare.	Cooking qualities. [a]
				cavans	*kg.*	
Pinursigui	4	5	122	55.929	2558.5	Poor
Quinastila	5	6	135	55.072	2532.3	Good
Binuncaue	7	5	150	54.66	2508.1	Fair
Kinanda	5	8	130	49.279	2324.3	Good
Sanglay puti	5	4	121	43.644	1950.3	Poor
Tiniaong	4	4	121	43.512	1903.7	Poor
Inintiw	4	7	127	41.129	1871.0	Poor
Binundoc	4	5	148	40.62	1863.0	Poor
Binicol	5	7	147	39.777	1853.5	Poor
Guluyang pula	5	5	139	38.363	1844.4	Poor
Sinacoban	4	7	149	36.787	1797.0	Poor
Kinagaykay	5	8	147	36.655	1766.5	Poor
Putyocanon	5	8	137	34.592	1494.0	Poor
Maliro	5	10	137	34.323	1471.3	Poor
Bulandi	5	13	158	27.713	1384.2	Poor
Benguet	5	8	140	23.776	1122.2	Poor

[a] Cooking qualities are explained as follows: "Good cooking means when the rice kernels retain their shape after being cooked, yet they are soft and have good flavor. Fair cooking means when the rice kernels retain their shape after being cooked but are not soft. Poor cooking means when the rice kernels, after being cooked and allowed to cool, become hard and unpalatable."

The recommendations by the author are:

1. "As in each locality there are many varieties of upland rice cultured by the farmers, a variety test should be run in the locality or in the region where conditions are uniform to isolate and keep the most desirable varieties suited to prevailing conditions and exclude all the inferior ones that would not in any way be profitable. In this connection, it must be borne in mind that productivity or any single character can not be the only criterion in judging superiority of varieties; all the merits of the varieties should be scrutinized and well balanced before discarding varieties as undesirable ones".

2. "Since our small farmers do not have the facilities to run a variety test, the government should do this work and provide them with seeds of superior varieties known to be suited to their local conditions".

Abstract by Rafael M. Piguing.

COLLEGE AND ALUMNI NOTES

President Benton visited the College November 4 to 6. On the evening of the 4th, the students formed a torch-light parade and marched to Copeland House to escort the President to Botany Hall where a program was rendered in his honor. Arturo Benzon, representing the student body, welcomed the guest of honor and pointed out the necessity for improvement in the living conditions on the Campus. Mr. Delfin Divinagracia spoke on the "Los Baños Spirit". Doctor Roxas made a few remarks emphasizing the virtue of self-reliance. Dean Baker introduced President Benton who delivered the address of the evening. He spoke of the need of a permanent mill tax as a source for University revenue, and further pointed out the need for the co-operation of students, faculties, and the administration to solve the problems of the University.

The College of Agriculture Alumni Association held its annual luncheon in the court of the Seed Laboratory at noon on November 5. President Benton, Mr. Lopez of the Chamber of Agriculture, and Dean Baker were the guests of honor. Doctor Mirasol presided as toastmaster opening the occasion with a brief address in which he placed upon all active Alumni the task of convincing the people of the Islands, both by example and active propaganda, of the value of technical training in agriculture. He then introduced the speakers whose names and themes follow:

Dr. R. B. Espino, of the Department of Agronomy, read a very instructive paper dealing with problems involved in the cultivation of coconut and abacá with which the Division of Fiber and Oil Plants is chiefly concerned. As regards coconut, he suggested the possibilities in the recently proposed process of oil extraction from grated nuts without the intermediate and uneconomical copra sub-product. Concerning abacá, Doctor Espino advocated the establishment of test stations in the major producing regions of the Philippines where varietal research could be effectively carried on. For the improvement of abacá exports there were proposed several laws designed to standardize the product and retain priority in the market.

Dr. Francisco A. Quisumbing, of the Department of Chemistry, read a paper in which he presented the opportunities awaiting active young Filipinos in the field of biological, agricultural, and industrial chemistry. The various undeveloped but abundant Philippine sources of alcohol, starch, and sugar were dealt with in detail. His paper was an elaboration of the introduction to his "Philippine Contributions on Agricultural, Biological and Industrial Chemistry" which appeared in the *Philippine Agriculturist*, volume X, number 3.

Professor Inocencio Elayda, of the Department of Agronomy, spoke on the essential point of bringing the College, its men, methods, and results to the farmer in the field. He did not underestimate the difficulties of accomplishing this and he briefly outlined the plans for the extension service of the College of which he has charge and the prospects of development in this recognized function of agricultural education.

Dr. N. B. Mendiola, of the Department of Agronomy, advocated the organization of a University Department of Genetics to include eugenics and plant and animal breeding. The latter two are now organized at the College of Agriculture under the Department of Agronomy and Animal Husbandry, respectively. In Doctor Mendiola's opinion the two should be consolidated and expanded to include eugenics. He strongly held that the improvement of the Filipino race was as possible as and even more important than the improvement of either rice or the horse.

Dr. M. L. Roxas, of the Department of Chemistry, presented the necessity of research in nutrition to reorganize on a higher efficiency the average native diet. He lamented the lack of a "milk-products safety zone" in the present diet. Doctor Roxas suggested that the infant mortality rate in the Islands could be lessened fundamentally by a proper diet for child-bearing mothers. The solution of most physical deficiencies of our people were said to rest upon the point of good nutrition.

Mr. Vicente Lopez, of the Chamber of Agriculture, addressed the Alumni in Spanish. He mentioned the depression which low prices have recently brought to the farming community, the necessity for organizing production on a lower cost basis, the need for a strict agrarian policy on the part of the Government, and the assistance that technical research in the College may afford the planters of the Philippines.

Dean Baker in response to a toast, "Why is a College of Agriculture?" unhesitatingly gave as the only answer, "For the students." The Dean insisted on such alumni activity as would consistently keep in contact with and offer all possible assistance to graduates of the College. He deplored the fact that the local demand for agricultural technicians sometimes threw our men into isolated and responsible government positions without either maturity of experience, a uniform backing or supervision. He endorsed the system of fellowships abroad and asked for its expansion.

President Benton responded to his hosts with an address in which he described alumni bureau methods as now practiced in certain American Universities. The President emphasized the point of extension service made by Professor Elayda and explained that the same would have his administrative support. The President assured the Alumni of the very responsible task which their College and country lays upon them and wished them the highest degree of success both as individuals and as a body in service to the State.

On November 1 President Butterfield of the Massachusetts Agricultural College, in company with Mrs. Butterfield and President Benton, visited the College. Doctor Butterfield delivered a timely address to the student assembly in which he stressed the more recent developments in agricultural progress: The perception of business values on the part of the farmer; the realization the world aspect of agriculture; the tremendous advancement in agricultural economics and rural sociology; and in the United States, especially, the organization of "ruralists" for effective political participation. Doctor Butterfield came to the Philippines from China where he is engaged as a member of a committee of American experts who are inspecting mission education with a special view to standardizing courses in agriculture.

Scribner's Magazine for September contains Professor Yule's "Japan's New Woman." Therein the observer delineates the strong movement among the women of Japan for emancipation from their traditional and unenviable social status; for better education of her sex; for a place in the professions; and for a voice in politics. In conclusion Professor Yule writes:

> "Apparently Japan's new woman is giving her vigor and sagacity to loosening the fetters of custom that keep her from living the life of a freeborn individual; to opening the doors that shut her from the 'boundless realm' which should be hers to enter and possess * * * Unspoiled by experience, unhindered by traditional practice, she can be sincere, frank, direct in her methods; open and aboveboard in her plans of operation—a precursor of the new diplomacy, talked about at council tables in the near past."

The Bachelors Club of the College of Agriculture gave an assembly ball in honor of President Benton on the evening of November 5.

Anastacio G. Teodoro, B. Agr. '18, arrived from the United States on November 8 and immediately assumed duties as Instructor in the College in the Department of Rural Engineering. He was first employed on Doctor Copeland's Farm at Chico and attended two quarters at Leland Stanford. Mr. Teodoro was appointed a pensionado of the University of the Philippines in 1919. He specialized in agricultural engineering at Wisconsin and later at Cornell where he received his Master's degree in 1921. During the summer of 1921 Mr. Teodoro attended classes in education at Harvard; for the School year 1921-22 he was offered a fellowship at Iowa but arrangements could not be made for his acceptance.

Andres Goseco, B. Agr. '20, formerly employed at Doctor Copeland's farm at Chico, California, arrived in the Islands on November 8 and visited the Campus for several days. Mr. Goseco completed courses in cattle management in the University of California. He will engage in live stock raising in Mindanao.

The College of Agriculture Alumni Association has taken under advisement the erecting of an Alumni Hall on the Campus. The hall would afford a place of residence for local Alumni and a general rendezvous for all members of the Association. The financing of the project would be made possible by means of a loan guaranteed by a twenty-five per cent lien on the aggregate salaries of all Alumni on the staff of the College.

Joaquin Gonzalez, B. Agr. '18, a brother of Professor Bienvenido Gonzalez of this College, was married on November 3 to Miss Julia Salgado. The marriage ceremony took place in the Chapel of the Capuchinos in Intramuros, Manila. The honeymoon was spent in Sibul, Bulakan, and Los Baños, Laguna. Mr. Gonzalez is engaged in private farming in Apalit, Pampanga.

On October 23, Dr. and Mrs. R. B. Espino were hosts to several faculty members and their wives at their home in San Antonio. The affair was a *tayo tayo lamang* party and was highly enjoyable.

Subsequent to the resignation of Doctor Mirasol as president of the College of Agriculture Alumni Association and in the absence of Vice-President Gregorio Francisco, Doctor Espino was elected Acting President of the Association, effective September 29, 1921.

Mr. Mariano F. Villaraza, B. Agr., '20, and wife, née Miss Sotera Reyes of Imus, Cavite, announce the birth of a son on September 28, 1921.

The College Co-operative Co., Inc. has completed the addition to its sales room and has added a barber shop. The company has recently undertaken with success the sale on the installment plan of bicycles for the Pacific Commercial Company. Doctor Espino is manager of the Company.

Nemesio Catalan, '20, who has been a graduate assistant in Agronomy, has passed the United States Military Service examination and was commissioned a second lieutenant of Scouts. He expects to be put in charge of reforestation at Corregidor.

WEATHER OBSERVATIONS, MAY, 1920

Observer—R. P. Estioko

At College

Date.	Rainfall.		Temperature.				Wind.		Cloudiness.
	Daily.	Weekly.	Maximum.	Minimum.	Daily.	Weekly.	Daily.	Weekly.	
May	*mm.*	*mm.*	*°C.*	*°C.*	*°C.*	*°C.*	*miles*	*miles*	
1	0	0	33.3	24.2	28.7	28.4			¾ cloudy
2	1.0		33.0	23.6	28.3		17.5		½ cloudy
3	4.5		31.5	23.6	27.1		23.1		¾ cloudy
4	17.2		32.5	24.4	28.4		21.1		½ cloudy
5	0		33.3	23.0	28.2		15.2		½ cloudy
6	0		34.5	23.8	29.1		35.1		½ cloudy
7	0		34.5	23.5	29.0		25.7		½ cloudy
8	56.6	79.3	30.0	24.4	27.2	28.2	22.5	160.2	¾ cloudy
9	33.8		31.5	23.6	27.1		25.0		cloudy
10	20.1		30.8	23.8	27.3		10.1		¾ cloudy
11	0		30.0	23.8	26.9		11.4		cloudy
12	0		31.0	22.9	26.9		10.2		cloudy
13	T		31.5	23.1	27.3		19.9		¾ cloudy
14	2.3		30.0	23.4	26.7		28.4		¾ cloudy
15	13.5	69.7	28.5	23.6	26.0	26.9	39.0	144.0	cloudy
16	7.5		29.5	22.4	25.9		65.9		¾ cloudy
17	7.0		28.8	23.5	26.1		50.4		cloudy
18	.5		29.5	22.6	26.0		49.7		¾ cloudy
19	T		28.6	24.1	26.3		28.2		cloudy
20	19.5		29.8	23.6	26.7		51.7		cloudy
21	43.3		28.2	22.8	25.5		49.0		cloudy
22	3.5	81.3	29.4	22.9	26.1	26.1	47.9	342.8	¾ cloudy
23	.0		31.8	23.4	27.6		59.1		¼ cloudy
24	5.7		31.2	24.1	27.6		50.1		¾ cloudy
25	.0		31.0	24.4	27.7		54.3		¾ cloudy
26	1.5		31.2	24.1	27.6		49.8		cloudy
27	0		31.0	24.6	27.8		55.8		¾ cloudy
28	7.0		31.0	23.1	27.0		67.9		½ cloudy
29	T	14.2	31.0	22.8	26.8	27.4	53.2	390.2	¾ cloudy
30	17.5		30.8	23.6	27.2		59.4		cloudy
31	0		31.3	24.1	27.7		67.4		½ cloudy
Monthly		262.0	30.7	23.6	27.1	27.2	38.1	1181.2	

On Mount Makiling

Station on Mount Makiling.	Dates.	Rainfall.	Temperature.		
			Maximum.	Minimum.	Mean.
College Coffee Plantation	May 3 to May 9	20.7	35.0	19.2	27.1
	May 10 to May 16	14.7	35.8	19.5	27.6
	May 17 to May 23	49.8	34.7	20.0	27.3
	May 24 to May 30	15.1	34.8	20.2	27.5
450 m. Elevation	May 3 to May 9	11.2			
	May 10 to May 16	51.1			
	May 17 to May 23	65.4			
	May 24 to May 30	16.2			
Summit	May 2 to May 8	7.3	23.1	19.6	21.4
	May 9 to May 15	33.5	22.3	19.0	20.7
	May 16 to May 22	45.2	20.8	18.2	19.5
	May 23 to May 29	4.1	24.0	19.3	21.7

WEATHER OBSERVATIONS, JUNE, 1920.

Observer—R. P. Estioko

At College

Date.	Rainfall.		Temperature.				Wind.		Cloudiness,
	Daily.	Weekly.	Maximum.	Minimum.	Daily.	Weekly.	Daily.	Weekly.	
June	*mm.*	*mm.*	*°C.*	*°C.*	*°C.*	*°C.*	*miles*	*miles*	
1	O		32.0	23.6	27.8		55.6		½ cloudy
2	O		31.0	23.6	27.3		69.4		cloudy
3	21.2		30.2	24.4	27.3		72.0		cloudy
4	4.3		30.5	24.6	27.5		77.8		cloudy
5	4.3	31.9	28.5	23.0	25.8	27.2	55.3	446.9	cloudy
6	O		30.8	23.6	27.2		48.1		cloudy
7	T		28.8	23.6	26.2		47.0		cloudy
8	41.9		28.2	25.2	26.7		50.0		cloudy
9	21.0		29.0	22.9	25.9		61.2		¾ cloudy
10	.5		29.5	22.6	26 1		60.3		cloudy
11	O		30.5	22.6	26.5		28.1		½ cloudy
12	.5	63.9	31.0	22.6	26.8	26.5	103.8	398.5	¾ cloudy
13	2.6		31.0	23.6	27.3		54.1		¾ cloudy
14	O		31.5	23.4	27.5		62.6		cloudy
15	O		30.6	23.6	27.1		56.7		cloudy
16	.3		31.8	23.6	27.7		62.3		¾ cloudy
17	26.1		30.0	24.2	27.1		70.3		½ cloudy
18	.8		30.0	24.6	27.3		53.2		cloudy
19	O	29.8	29.9	24.4	27.1	27.3	73.9	433.1	½ cloudy
20	O		31.9	24.4	28.2		53.8		¾ cloudy
21	O		32.0	24.1	28.0		55.8		¾ cloudy
22	1.7		30.2	24.2	27.2		71.9		cloudy
23	O		30.6	24.1	27.3		55.1		¾ cloudy
24	1.5		31.0	24.6	27.8		56.5		cloudy
25	2.5		29.4	24.4	26.9		58.9		cloudy
26	T	5.7	28.5	24.4	26.5	27.4	63.6	415.5	cloudy
27	T		30.6	23.8	27.2		89.4		cloudy
28	5.6		28.0	24.2	26.1		90.6		cloudy
29	4.7		28.0	24.1	26.1		83.5		cloudy
30	6.0		25.5	22.6	24.0		94.7		cloudy
Monthly		145.5	30.0	23.8		26.9		1925.4	

On Mount Makiling

Station on Mount Makiling.	Dates.	Rainfall	Temperature.		
			Maximum.	Minimum.	Mean,
College Coffee Plantation	May 31 to June 5	31.6	35.5	20.0	27.7
	June 6 to June 12	31.5	35.8	20.4	28.1
	June 13 to June 19	51.8	34.6	19.4	27.0
	June 20 to June 26	29.6	34.0	20.2	27.1
	June 27 to July 3	29.6	35.5	20.5	28.0
450 Meters Elevation	May 30 to June 5	31.1			
	June 6 to June 12	33.2			
	June 13 to June 19	41.7			
	June 20 to June 26	30.5			
	June 27 to July 3	34.1			
Summit	May 30 to June 5	41.1	21.8	19.4	20.6
	June 6 to June 12	25.4	22.8	18.9	20.9
	June 13 to June 19	25.4	23.4	20.3	21.9
	June 20 to June 26	53.4	21.8	18.8	20.3
	June 27 to July 3	49.2	21.4	19.0	20.2

WEATHER OBSERVATIONS, JULY, 1920.

Observer—R. P. Estioko

At College.

Date.	Rainfall.		Temperature.				Daily.	Weekly.	Cloudiness.
	Daily.	Weekly.	Maximum.	Minimum.	Daily.	Weekly.			
July	*mm.*	*mm.*	*°C.*	*°C.*	*°C.*	*°C.*	*miles*	*miles*	
1	T		29.5	23.6	26.5		90.8		cloudy
2	O		30.0	23.8	26.9		58.9		¾ cloudy
3	1.6	17.9	30.2	24.1	27.1	26.3	65.9	573.8	cloudy
4	18.7		27.0	23.6	25.3		47.9		cloudy
5	26.1		28.0	22.6	25.3		69.7		cloudy
6	12.0		30.0	23.1	26.5		39.7		cloudy
7	3.2		29.4	23.4	26.4		60.4		cloudy
8	2.2		29.9	23.6	26.7		147.6		cloudy
9	16.8		28.5	23.4	25.9		70.9		cloudy
10	6.1	85.1	27.6	23.4	25.5	25.9	48.7	484.9	cloudy
11	18.2		26.6	23.6	25.1		43.4		cloudy
12	5.5		25.8	23.6	24.7		63.1		cloudy
13	2.3		27.2	24.0	25.6		205.4		cloudy
14	T		29.5	24.9	27.2		216.4		cloudy
15	18.7		30.1	25.4	27.7		141.0		cloudy
16	2.4		30.9	25.8	28.3		131.8		cloudy
17	27.9	75.0	28.5	25.6	27.0	26.5	139.6	940.7	cloudy
18	34.0		25.0	25.6	25.3		322.9		cloudy
19	26.7		29.0	24.1	26.5		287.2		cloudy
20	9.0		28.4	26.4	27.4		336.6		cloudy
21	14.3		27.5	26.1	26.8		415.0		cloudy
22	9.0		27.8	26.8	27.3		434.1		cloudy
23	T		28.5	27.6	28.0		460.2		cloudy
24	T	93.0	28.9	27.6	28.2	27.1	413.0	2669.0	cloudy
25	20.3		28.8	26.1	27.6		298.7		cloudy
26	8.4		29.6	22.0	25.8		121.5		cloudy
27	6.7		29.8	23.4	26.6		55.7		cloudy
28	6.3		26.5	23.3	24.9		75.3		cloudy
29	8.2		29.8	22.8	26.3		94.5		cloudy
30	.7	52.0	32.0	23.1	27.5		87.1		cloudy
31	1.4		31.5	23.6	27.5	26.6	56.6	799.4	½ cloudy
Monthly		306.7	28.8	24.4	26.6	26.6		5109.6	

On Mount Makiling

Station on Mount Makiling.	Dates.	Rainfall.	Temperature.		
			Maximum.	Minimum.	Mean.
College Coffee Plantation.....	July 4 to July 10	92.6	35.0	19.8	27.4
	July 11 to July 17	98.6	34.8	20.5	27.6
	July 18 to July 24	181.6	33.0	20.4	26.7
	July 25 to July 31	102.1	33.8	20.7	27.3
450 Meters Elevation.....	July 4 to July 10	96.4			
	July 11 to July 17	101.0			
	July 18 to July 24	185.5			
	July 25 to July 31	114.6			
Summit.....	July 4 to July 10	84.7	21.4	19.4	20.4
	July 11 to July 17	103.4	20.2	19.2	19.7
	July 18 to July 24	145.3	20.2	19.3	19.7
	July 25 to July 31	64.7	20.2	18.8	19.5

WEATHER OBSERVATIONS, AUGUST, 1920.

R. P. Estioko—Observer

At College

Date	Rainfall		Temperature				Wind.		Cloudiness.
	Daily.	Weekly.	Maximum.	Minimum.	Daily.	Weekly.	Daily.	Weekly.	
August	*mm.*	*mm.*	*°C*	*°C*	*°C*	*°C*	*miles*	*miles*	
1	0		32.2	23.5	27.9		72.3		¾ cloudy
2	0		31.5	23.6	27.5		77.8		¾ cloudy
3	0		32.2	23.6	27.9		80.9		¾ cloudy
4	0		31.8	24.1	28.0		87.2		½ cloudy
5	0		32.2	23.9	28.0		82.3		¾ cloudy
6	0		32.5	23.8	28.2		72.0		½ cloudy
7	0	0	32.3	23.6	27.9	27.9	46.9	519.4	½ cloudy
8	0		32.4	23.6	28.0		71.4		¾ cloudy
9	0		31.6	23.8	27.7		67.8		½ cloudy
10	0		31.8	24.1	28.0		51.8		½ cloudy
11	0		32.5	23.8	28.0		40.7		½ cloudy
12	0		30.3	23.6	27.0		55.8		¾ cloudy
13	T		31.7	23.6	27.6		50.8		cloudy
14	T	T	32.0	23.6	27.8	27.7	135.5	473.8	cloudy
15	1.4		32.0	23.1	27.6		112.3		¾ cloudy
16	23.1		31.2	22.4	26.8		50.8		¾ cloudy
17	11.5		31.0	22.9	26.9		51.2		¾ cloudy
18	1.7		29.2	23.4	26.3		45.1		¾ cloudy
19	71.1		31.0	22.6	26.8		35.0		¾ cloudy
20	12.2		30.4	22.6	26.5		55.6		½ cloudy
21	2.0	123.0	31.0	22.6	26.8	26.8	92.2	442.2	¾ cloudy
22	0		29.0	23.6	26.3		56.3		cloudy
23	1.5		30.2	23.4	26.8		51.7		cloudy
24	1.7		31.0	23.4	27.2		55.2		cloudy
25	5.5		29.6	23.2	26.4		41.3		cloudy
26	10.2		30.5	23.1	26.8		59.6		¾ cloudy
27	10.4		27.8	23.2	25.5		35.2		cloudy
28	3.3	32.6	28.5	23.0	25.8	26.4	78.3	377.6	cloudy
29	55.0		27.0	23.1	25.0		85.8		cloudy
30	T		28.5	23.6	25.8		63.9		cloudy
31	31.1		26.5	23.1	24.8		52.0		cloudy
Monthly		241.7	30.7	23.4	27.0			2014.7	

On Mount Makiling

Station on Mount Makiling.	Dates.	Rainfall.	Temperature.		
			Maximum.	Minimum.	Mean.
College Coffee Plantation	Aug. 1 to Aug. 7	4.8	34.8	20.5	27.6
	Aug. 8 to Aug. 14	51.6	34.0	20.0	27.0
	Aug. 15 to Aug. 21	65.2	33.4	19.8	26.6
	Aug. 22 to Aug. 28	36.9	34.5	20.0	27.3
	Aug. 29 to Sept. 4	358.4	33.6	19.8	26.7
450 Meters Elevation	Aug. 1 to Aug. 7	5.2			
	Aug. 8 to Aug. 14	52.6			
	Aug. 15 to Aug. 21	67.4			
	Aug. 22 to Aug. 28	48.7			
	Aug. 29 to Sept. 4	367.4			
Summit	Aug. 1 to Aug. 7	6.3	21.5	19.4	20.5
	Aug. 8 to Aug. 14	62.0	21.5	18.7	20.1
	Aug. 15 to Aug. 21	103.4	21.9	19.3	20.6
	Aug. 22 to Aug. 28	51.0	22.0	19.2	20.6
	Aug. 29 to Sept. 4	253.2	21.1	19.3	20.2

WEATHER OBSERVATIONS, SEPTEMBER, 1920

Observer—R. P. Estioko

At College

Date	Rainfall.		Temperature.				Wind.		Cloudiness.
	Daily.	Weekly.	Maximum.	Minimum.	Daily.	Weekly.	Daily.	Weekly.	
September	*mm.*	*mm.*	*°C.*	*°C.*	*°C.*	*°C.*	*miles.*	*miles.*	
1	23.2		29.5	13.1	26.3		270.5		cloudy
2	48.4		27.0	23.6	25.3		167.2		cloudy
3	7.2		29.8	25.1	27.4		230.9		cloudy
4	25.5	190.4	28.0	25.4	26.7	25.9	160.9	1031.2	cloudy
5	.9		29.0	24.1	26.6		140.3		cloudy
6	.6		31.8	22.6	27.2		66.7		¾ cloudy
7	T		29.7	22.8	26.2		45.8		½ cloudy
8	.0		29.2	23.6	26.4		48.0		cloudy
9	.0		29.5	24.4	27.0		63.7		cloudy
10	2.2		32.5	22.1	27.3		60.9		¾ cloudy
11	O	3.7	32.6	23.6	28.1	27.0	44.0	469.4	¾ cloudy
12	O		31.6	23.6	27.3		91.1		½ cloudy
13	4.8		29.2	23.8	26.5		59.7		½ cloudy
14	O		30.5	22.8	26.5		78.0		½ cloudy
15	O		31.2	23.3	27.4		55.1		¾ cloudy
16	O		32.0	22.9	27.4		43.9		¾ cloudy
17	O		32.0	22.6	27.3		31.3		½ cloudy
18	2.4	7.2	28.5	23.0	25.8	26.9	103.3	462.4	½ cloudy
19	28.3		27.5	23.1	25.3		56.0		cloudy
20	35.0		27.0	23.1	25.0		43.6		cloudy
21	6.2		28.4	22.6	25.5		48.1		½ cloudy
22	T		29.0	23.4	26.2		47.9		½ cloudy
23	27.8		26.0	23.1	24.6		62.6		cloudy
24	19.1		25.0	23.1	24.0		48.3		cloudy
25	64.7	181.1	25.0	22.6	23.8	24.9	80.0	368.5	cloudy
26	13.6		27.5	22.6	25.0		45.5		cloudy
27	22.5		28.5	23.6	26.1		81.8		cloudy
28	2.4		31.0	23.6	27.3		71.4		½ cloudy
29	O		30.8	24.8	27.8		118.0		¾ cloudy
30	T		28.8	23.4	26.1		47.2		cloudy
Monthly		334.8	29.2	23.4	26.3			2511.7	

On Mount Makiling

Station on Mount Makiling.	Dates.	Rainfall.	Temperature.		
			Maximum.	Minimum.	Mean.
Coffee Plantation	Sept. 5 to Sept. 11	29.2	34.5	19.8	27.2
	Sept. 12 to Sept. 18	37.1	36.5	20.0	28.3
	Sept. 20 to Sept. 26	201.4	35.0	19.8	27.4
	Sept. 27 to Oct. 3	104.0	36.5	19.5	28.0
450 Meters Elevation	Sept. 5 to Sept. 11	24.6			
	Sept. 13 to Sept. 19	31.2			
	Sept. 20 to Sept. 26	205.3			
	Sept. 27 to Oct. 3	102.4			
Summit	Sept. 5 to Sept. 11	29.3	22.6	19.1	20.9
	Sept. 12 to Sept. 18	21.0	21.3	19.3	20.3
	Sept. 19 to Sept. 25	107.6	20.3	19.0	19.6
	Sept. 26 to Oct. 3	56.5	22.9	19.2	21.0

WEATHER OBSERVATIONS, OCTOBER, 1920

Observer—R. P. Estioko

At College

Date.	Rainfall.		Temperature.				Wind.		Cloudiness.
	Daily.	Weekly.	Maximum.	Minimum.	Daily.	Weekly.	Daily.	Weekly.	
Oct.	*mm.*	*mm.*	*°C.*	*°C.*	*°C.*	*°C.*	*miles*	*miles*	
1	17.6		30.0	23.3	26.6		59.8		cloudy
2	T	56.1	30.0	23.6	26.8	26.5	58.1	481.8	cloudy
3	4.4		29.5	23.1	26.3		62.5		cloudy
4	.2		29.0	22.4	25.7		36.4		cloudy
5	.2		29.0	22.6	25.8		55.6		¾ cloudy
6	T		31.0	23.3	27.8		54.9		cloudy
7	71.7		28.2	22.8	25.5		40.0		cloudy
8	1.7		29.5	22.6	26.0		47.7		cloudy
9	T	78.2	29.2	22.6	25.9	26.1	48.3	345.4	¾ cloudy
10	O		30.0	22.8	26.4		55.9		½ cloudy
11	O		31.1	23.6	26.8		46.8		¾ cloudy
12	O		30.0	22.6	26.3		48.1		¾ cloudy
13	O		28.8	22.3	25.6		40.5		cloudy
14	11.1		27.5	23.6	25.5		45.0		cloudy
15	18.1		27.0	23.3	25.2		35.5		cloudy
16	7.2	36.4	27.0	23.0	25.2	25.9	32.0	303.8	cloudy
17	2.1		27.8	22.8	25.3		34.7		cloudy
18	O		27.5	23.0	25.2		35.0		cloudy
19	11.5		27.0	22.2	24.6		90.5		cloudy
20	12.4		28.0	22.4	24.8		48.8		cloudy
21	.4		29.5	23.0	26.2		64.9		cloudy
22	.5		29.0	23.2	25.8		93.6		cloudy
23	10.3	37.2	27.5	22.6	25.1	25.3	79.8	447.3	cloudy
24	T		27.0	22.6	24.8		46.4		cloudy
25	.8		28.3	22.6	25.3		138.8		cloudy
26	T		27.5	23.6	25.3		77.0		cloudy
27	O		28.5	22.8	25.7		77.1		cloudy
28	O		27.0	22.9	24.9		86.7		cloudy
29	O		27.6	22.9	24.3		84.9		cloudy
30	O	.8	27.5	22.8	25.1	25.1	74.0	584.9	cloudy
31	O	O	28.2	22.8	25.5		56.6		cloudy
Monthly		170.2	28.5	22.9	25.7		59.15	1865.9	

On Mount Makiling

Station on Mount Makiling.	Dates.	Rainfall.	Temperature.		
			Maximum.	Minimum.	Mean.
College Coffee Plantation	Oct. 3 to Oct. 9	95.6	33.8	20.0	26.9
	Oct. 10 to Oct. 16	102.1	33.5	20.5	27.0
	Oct. 17 to Oct. 23	41.0	32.0	19.0	25.5
	Oct. 24 to Oct. 30	5.8	33.2	20.6	26.9
450 Meters Elevation	Oct. 3 to Oct. 9	104.6			
	Oct. 10 to Oct. 16	111.2			
	Oct. 17 to Oct. 23	56.8			
	Oct. 24 to Oct. 30	5.6			
Summit	Oct. 3 to Oct. 9	108.7	20.6	17.9	19.2
	Oct. 10 to Oct. 16	72.6	20.7	17.9	19.3
	Oct. 17 to Oct. 23	52.4	20.1	17.3	18.7
	Oct. 24 to Oct. 30	8.5	18.3	17.7	18.0

WEATHER OBSERVATIONS, NOVEMBER, 1920.

Observer—R. P. Estioko

At College

Date.	Rainfall.		Temperature.				Wind.		Cloudiness.
	Daily.	Weekly.	Maximum.	Minimum.	Daily.	Weekly.	Daily.	Weekly.	
November	*mm.*	*mm.*	*°C.*	*°C.*	*°C.*	*°C.*	*miles*	*miles*	
1	3.0		26.8	21.6	24.2		72.7		cloudy
2	5.8		28.0	22.6	25.1		91.0		¾ cloudy
3	7.8		26.3	23.6	24.9		99.7		cloudy
4	50.9		26.0	24.2	25.1		201.7		cloudy
5	O		30.0	24.1	27.1		208.4		¾ cloudy
6	O	67.5	30.0	22.9	26.4	25.5	74.1	814.2	cloudy
7	10.6		29.0	23.1	26.1		54.2		cloudy
8	O		27.8	23.6	25.7		59.9		¾ cloudy
9	O		28.0	21.8	24.9		43.7		cloudy
10	O		29.5	23.2	26.3		49.5		¾ cloudy
11	O		29.0	21.6	25.3		55.2		½ cloudy
12	.4		29.0	23.6	26.3		82.6		cloudy
13	49.5	60.5	25.4	24.2	24.8	25.6	40.7	384.8	cloudy
14	68.0		23.2	23.6	23.4		67.5		cloudy
15	38.3		25.0	22.4	23.7		48.6		cloudy
16	24.4		26.0	22.6	24.3		55.2		cloudy
17	4.4		25.5	22.6	24.1		37.3		cloudy
18	2.0		27.8	22.6	25.2		98.7		cloudy
19	1.9		27.0	23.5	25.2		66.2		cloudy
20	T	139.0	28.4	23.4	25.9	24.5	66.1	439.6	¾ cloudy
21	O		27.2	23.8	25.5		81.7		¾ cloudy
22	10.5		26.8	23.6	25.2		64.4		cloudy
23	2.5		27.2	24.1	25.7		83.3		¾ cloudy
24	17.2		27.0	23.6	25.3		73.9		cloudy
25	.3		27.4	22.4	24.9		61.0		cloudy
26	O		28.0	22.6	25.3		87.3		½ cloudy
27	O	30.5	28.0	22.6	25.3	25.3	94.0	545.7	½ cloudy
28	6.1		27.0	22.6	24.9		47.2		cloudy
29	10.0		27.2	22.6	24.9		59.3		cloudy
30	1.5		27.5	22.0	24.7		57.0		cloudy
Monthly		315.1	27.4	23.0	25.2			2282.2	

On Mount Makiling

Station on Mount Makiling.	Dates.	Rainfall.	Temperature.		
			Maximum.	Minimum.	Mean.
College Coffee Plantation	Oct. 31 to Nov. 6	80.1	31.0	18.5	24.7
	Nov. 7 to Nov. 13	98.6	32.9	19.6	26.3
	Nov. 14 to Nov. 20	108.1	32.5	18.6	25.6
	Nov. 21 to Nov. 27	37.9	33.2	20.5	26.9
450 Meters Elevation	Oct. 31 to Nov. 6	81.5			
	Nov. 7 to Nov. 13	101.2			
	Nov. 14 to Nov. 20	109.7			
	Nov. 21 to Nov. 27	38.4			
Summit	Oct. 31 to Nov. 6	72.6	18.9	17.1	18.0
	Nov. 7 to Nov. 13	55.6	20.5	18.1	19.3
	Nov. 14 to Nov. 20	88.5	19.6	18.5	19.6
	Nov. 21 to Nov. 27	39.1	19.7	18.7	19.2

WEATHER OBSERVATIONS, DECEMBER, 1920.

Observer—R. P. Estioko

At College.

Date.	Rainfall.		Temperature.				Wind.		Cloudiness.
	Daily.	Weekly.	Maximum.	Minimum.	Daily.	Weekly.	Daily.	Weekly.	
Dec.	*mm.*	*mm.*	*°C.*	*°C.*	*°C.*	*°C.*	*miles.*	*miles.*	
1	30.1		26.3	23.0	24.6		45.8		cloudy
2	11.4		26.5	23.6	25.0		52.2		cloudy
3	10.3		26.5	23.8	25.1		49.5		cloudy
4	2.6	72.0	28.2	22.6	25.4	25.1	29.6	340.6	cloudy
5	2.6		25.0	22.2	23.6		38.6		cloudy
6	27.1		26.5	23.6	25.0		69.2		cloudy
7	9.2		27.0	23.6	25.3		23.6		cloudy
8	2.7		27.0	23.1	25.0		46.7		cloudy
9	T		27.0	23.6	25.3		41.2		cloudy
10	3.0		28.0	22.6	25.3		32.1		cloudy
11	2.1	46.7	28.0	23.6	25.8	25.1	35.0	286.4	cloudy
12	O		27.6	24.0	25.3		78.2		cloudy
13	6.6		27.4	23.6	25.5		55.7		cloudy
14	O		27.0	22.6	24.8		41.3		cloudy
15	13.0		27.0	22.6	24.8		49.5		cloudy
16	57.7		25.8	23.1	24.4		174.3		cloudy
17	6.5		26.5	22.5	24.4		153.3		cloudy
18	O	83.8	27.0	22.6	24.8	25.0	125.1	677.4	cloudy
19	O		26.8	22.6	24.7		102.4		½ cloudy
20	T		25.3	22.6	26.9		87.9		½ cloudy
21	O		25.0	21.4	23.2		112.6		½ cloudy
22	O		25.0	20.6	26.8		81.1		¼ cloudy
23	O		25.2	18.6	21.9		81.3		clear
24	6.7		23.5	19.5	21.5		40.9		¾ cloudy
25	O	6.7	23.6	19.3	21.4	22.8	58.3	564.5	cloudy
26	3.4		23.8	19.6	21.7		53.8		¾ cloudy
27	0.8		25.6	20.8	23.2		92.8		cloudy
28	T		25.4	21.1	23.2		130.8		cloudy
29	O		26.0	21.6	23.8		67.1		½ cloudy
30	2.9		26.5	21.1	23.8		133.1		cloudy
31	T		25.4	21.2	23.3		89.2		cloudy
Monthly		198.7	26.2	22.1	24.2		73.5	2277.2	

On Mount Makiling

Station on Mount Makiling.	Dates.	Rainfall.	Temperature.		
			Maximum.	Minimum.	Mean.
College Coffee Plantation	Nov. 28 to Dec. 5	87.6	32.0	19.5	25.8
	Dec. 6 to Dec. 12	99.4	30.0	20.0	25.0
	Dec. 13 to Dec. 19	98.9	31.0	20.2	25.6
	Dec. 20 to Dec. 26	18.4	30.7	17.8	24.2
	Dec. 27 to Jan. 2	14.8	28.5	16.0	22.3
450 Meters Elevation	Nov. 28 to Dec. 5	89.5			
	Dec. 6 to Dec. 12	96.0			
	Dec. 13 to Dec. 19	102.6			
	Dec. 20 to Dec. 26	19.7			
	Dec. 27 to Jan. 2	11.8			
Summit	Nov. 28 to Dec. 5	104.1	19.3	17.9	18.6
	Dec. 6 to Dec. 12	100.4	20.4	19.0	19.7
	Dec. 13 to Dec. 19	75.8	18.9	17.9	18.4
	Dec. 20 to Dec. 26	20.5	15.4	14.9	15.1
	Dec. 27 to Jan. 2	17.6	17.0	15.7	16.4